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Witch Flounder

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1.0 Background

Witch flounder, *Glyptocephalus cynoglossus*, is assessed as a unit stock from the Gulf of Maine southward. An analytical assessment was last conducted for this species in 2005 at the Groundfish Assessment Review Meeting (GARM 2005; NEFSC 2005). The 2005 assessment indicated average fishing mortality (ages 8-9, unweighted) increased from 0.26 in 1982 to 0.68 in 1985, declined to 0.22 in 1992, increased to 1.12 in 1996, then declined to 0.20 in 2004. Spawning stock biomass declined steadily from 16,897 mt in 1982 to 3,901 mt in 1996 and then increased to 21,175 mt in 2004. Since 1982, recruitment at age 3 has ranged from approximately 3 million fish (1984 year class) to 45 million fish (1997 year class) with a mean (1979 – 2002 year classes) of 15.5 million fish. The retrospective analysis indicates that average F was underestimated in the late 1990s and early 2000s, spawning stock biomass was consistently overestimated and recruitment was relatively consistently estimated, with notable exceptions of the 1995, 1996 and 1997 year classes which were considerably overestimated. NEFSC bottom trawl survey indices generally declined from the early 1960s to record low levels in the late 1980s and early 1990s. Since then survey indices increased but have exhibited a declining trend since 2000. Biological reference points were updated at the SARC 37 benchmark assessment in 2003 (NEFSC 2003, Wigley et al. 2003).

This report updates catch through 2006, survey indices through spring 2007, and estimates 2006 fishing mortality and spawning stock biomass. Biological reference points are estimated. Commercial witch flounder landings were updated for the 1994 to 2006 period, with negligible changes occurring for this unit stock species. The NEFSC and Massachusetts inshore survey indices have been revised using re-audited (NEFSC) and re-stratified (MA inshore) survey data.

2.0 The Fishery

Commercial landings

Significant proportions of the U.S. nominal catch have been taken from both the Georges Bank and Gulf of Maine regions. Canadian landings from both areas have been minor (not more than 68 mt annually). USA landings generally increased from the early 1960s, peaked in 1984 at 6,666 mt. Subsequently, landings declined and have fluctuated about 2,300 mt. In 2006, landings were 1,863 mt (Table G.1 and Figure G.1).

Sampling of landings has increased in recent years (Table G.2). When sampling was low, it was necessary to pool some quarters for some market categories. To estimate landings at age and mean weights at age, quarter, semi-annual or annual age-length keys were applied to corresponding commercial landings length frequency data by market category.

Discard estimation

Discards have been estimated for three fleets: northern shrimp trawl, large-mesh ($>=5.5$ inch) otter trawl, and small-mesh (<5.5 inch) otter trawl (Table G.3 and Figure G.1). The majority of discards occur between ages 1 to 6, and the discards are a small component of total catch (Figure G.1). The methods used to estimate fleet specific discards are given below.

Discards from the northern shrimp fishery were estimated using two methods used in a previous assessment (Wigley et al. 2003): when no observer data were available (1982-1988, 1998-2002), a regression of age 3 fish in the autumn NEFSC survey and observed discard rates was used to estimate ratios of discard weight to days fished (d/df) ratios. When observer data were available (1989-1997, 2003-2006), d/df ratios were calculated by fishing zone (a surrogate for depth). To estimate discard weight, the mean discard ratio (weighted by days fished in each fishing zone) was expanded by the days fished in the northern shrimp fishery. For 2003 to 2006, witch flounder discards in the northern shrimp fishery were estimated to be near zero. This is attributed to the short northern shrimp season in 2003-2004, the shift in effort to near-shore waters, inshore of the witch flounder distribution, and the relative low abundance of juvenile witch flounder in recent years. Witch flounder discarded in the northern shrimp fishery range in age from 0 to 6, with the majority at ages 1-3. The number of fish discarded in the shrimp fishery is small compared to the landings.

The estimation of large-mesh otter trawl discards is based upon two methods. For 1982 to 1988, a method which filters survey length frequency data through a commercial gear retention ogive and a culling ogive was used and then a semi-annual ratio estimator of survey-filtered ‘kept’ index to semi-annual numbers landed was used to expand the estimated ‘discard’ survey index to numbers of fish discarded at length (Wigley et al. 2003). For 1989 to 2006, an annual combined ratio of witch flounder discard weight to kept weight of all species ratios (d/k_{all}) was calculated from observer data. Total discard weight was derived by multiplying the d/k_{all} ratio by the commercial large-mesh otter trawl landings. Observed discard length frequencies are used to estimate discarded fish at length. Semi-annual numbers of fished discarded were apportioned to age using the corresponding seasonal NEFSC survey age/length key. Witch flounder discarded in the large-mesh otter trawl fishery range in age from 0 to 6, with the majority at ages 4 to 5. The number of fish discarded in the large-mesh otter trawl fishery is small compared to the landings. Discards at age and mean weights at age from the large-mesh otter trawl and northern shrimp trawl fleets are presented in Tables G.4 and G.5. and Figure G.2.

Witch flounder discards from the small-mesh otter trawl fisheries were also estimated using an annual combined ratio for this fleet and expanded to total discards by commercial landings of small-mesh otter trawls (Table G.3). The small-mesh otter trawl discard length frequencies for 1989 to 2006 were too sparse to estimate discarded fish at length. Given the possession regulations for this fleet, the commercial catch at age was used to apportion the small-mesh otter trawl discard weight to discards at age.

The total catch (landings + large-mesh otter trawl discards + shrimp trawl discards+ small-mesh discards) at age and mean weight at age are presented in Tables G.6 and G.7, and Figure G.3. The age composition data reveal strong 1979-1981 year classes; the 1989 and 1993 year classes also appear strong. The poor 1984 year class is also evident as well as a truncated age-structure since the early 1990’s. As observed in previous assessments, the mean weights-at-age in the catch continue to decline for fish age 6 and older (Figure G.4).

3.0 Research Vessel Survey Indices

The NEFSC bottom trawl survey indices generally declined from the early 1960s to record low levels in the late 1980s and early 1990s. Since then survey indices increased but have exhibited a declining trend since 2000 (Table G.8, Figures G.5a-b). Survey age compositions (mean number per tow at age) are presented in Table G.9, Figure G.6. The survey mean weights and mean lengths at age show a similar decline as reported in the commercial landings. A 5-year moving window of pooled maturity data from the NEFSC spring survey is used to estimate median age at maturity. The survey maturity-at-age has remained stable in recent years, with median A50 approximately age 6 (Figure G.7).

Both the Massachusetts inshore survey (Table G.10) and the Atlantic States Marine Fisheries Commission summer shrimp survey (Table G.11) show similar trends in abundance and biomass to the NEFSC surveys.

4.0 2006 Assessment

Input Data and analysis

The Virtual Population Analysis (VPA) is calibrated using the NOAA Fisheries Toolbox (NFT) ADAPT VPA version 2.7.7. Since the last assessment, only minor changes in software and data have occurred. The VPA formulation is the same as the previous assessment and uses catch (landings and discards for ages 3 to 11+) through 2006 and NEFSC spring and autumn survey abundance indices (ages 3 to 11+) through 2007 and 2006, respectively, to estimate stock sizes for ages 3 to 10. All indices are given equal weighting. Autumn survey indices are lagged forward one year and one age to calibrate with beginning year population sizes of the subsequent year. A flat-top partial recruitment vector is assumed, with full fishing mortality on ages 8 and older. The F on ages 10 and 11+ in all years prior to the terminal year is derived from the weighted estimates of Z on ages 8 and 9. Instantaneous rate of natural mortality (M) is assumed to be 0.15. Spawning stock biomass (SSB) is calculated at time of spawning (March) and mean weights at age calculated by the Rivard method. Annual maturity ogives are estimated using NEFSC spring maturity at age data through 2007, pooled by 5-year moving time blocks.

During the GARM3 Assessment Model Meeting, the panel concluded that there was sufficient data for an age-structured model that assumes negligible error in the catch-at-age. The panel also recommended exploring the retrospective pattern that has been present in previous assessments. VPA analyses were performed for a BASE case and a SPLIT case, where the survey time series was split between 1994 and 1995. This time split corresponds to changes in the commercial reporting methods as well as other regulatory management changes. Summary statistics of the two runs, as well as from the previous assessment, are given in Table G.12.

VPA BASE RUN results

The VPA BASE run had a mean square residual of 0.84, the coefficients of variation (CVs) for estimated stock size at age ranged between 24% and 66% (Table G.12), and the CVs for survey catchability coefficients (q) were consistent, ranging from 12% to 25%. Residual patterns from the NEFSC survey tuning indices are given in Figure G.8. The patterns appear random for most ages; however, for ages 7 and 10 there appear to be blocks of positive and negative residuals.

VPA results indicate average fishing mortality (ages 8-9, unweighted) increased from 0.26 in 1982 to 0.70 in 1988, declined to 0.23 in 1992, increased to 1.13 in 1996, then declined to 0.07 in 2006 (Table G.13 and Figure G.9). Spawning stock biomass declined steadily from 16,901 mt in 1982 to 3,906 mt in 1996, and has increased to 13,240 mt in 2006 (Tables G.13 and Figure G.9). Since 1982, recruitment at age 3 has ranged from approximately 3 million fish (2002 year class) to 32 million fish (1997 year class) with a mean of 13 million fish (median of 12 million; Table G.13 and Figure G.9). The addition of the 2002 to 2003 year classes to the stock-recruit data continued the negative trend observed in this relationship in the previous assessment (Figure G.9).

The retrospective analysis indicates that average F was underestimated in the late 1990s and early 2000s (Figure G.10); however, in more recent years, the pattern is not as evident.

Spawning stock biomass was consistently overestimated (Figure G.11). The retrospective analysis indicated a pattern of relatively consistent estimates of the number of age 3 recruits, with the notable exception of the 1995, 1996 and 1997 year classes, which were considerably overestimated (Figure G.12).

Bootstrap results suggest that the estimates of F and spawning stock biomass are relatively precise with CVs of 20% and 14%, respectively. The 80% confidence interval for $F_{2006}=0.07$ was 0.06 and 0.09, and for $SSB_{2006}=13,240$ mt the 80% confidence interval was 11,256 mt and 15,982 mt.

VPA SPLIT RUN results

The VPA SPLIT run had a mean square residual of 0.699, the coefficients of variation (CVs) for estimated stock size at age ranged between 33% and 62% (Table G.12), and the CVs for survey catchability coefficients (q) were consistent, ranging from 14% to 43%. Similar to the BASE RUN, residual patterns from the NEFSC survey tuning indices from the SPLIT RUN are given in Figure G.13. The patterns appear random for most ages; however, for ages 7 and 10 there appear to be blocks of positive and negative residuals.

VPA results indicate average fishing mortality (ages 8-9, unweighted) increased from 0.26 in 1982 to 0.70 in 1988, declined to 0.23 in 1992, increased to 1.14 in 1996, then declined to 0.17 in 2006 (Tables G.14 and G.15; Figure G.14). Spawning stock biomass declined steadily from 16,901 mt in 1982 to 3,851 mt in 1996, and has increased to 7,536 mt in 2003 and has declined to 5,920 in 2006 (Tables G.14 and G.15; Figure G.14). Since 1982, recruitment at age 3 has ranged from approximately 1 million fish (2002 year class) to 19 million fish (1997 year class) with a mean of 10.9 million fish (median of 11.8 million; Tables G.14 and G.15; Figure G.14). The addition of the 2002 to 2003 year classes to the stock-recruit data continued the negative trend observed in this relationship in the previous assessment (Figure G.14).

The retrospective analysis of the VPA SPLIT RUN indicates a random pattern for average F (Figure G.15) but spawning stock biomass was consistently underestimated during 1997-2000 and consistently overestimated during 2001-2004 (Figure G.16). The magnitude of the relative difference is lower than the VPA BASE RUN (Figure G.11). The retrospective analysis indicates a random pattern for Age 3 recruits (Figure G.17).

Bootstrap results of the VPA SPLIT RUN suggest that the estimates of F and spawning stock biomass are relatively precise with CVs of 20% and 14%, respectively. The 80% confidence interval for $F_{2006}=0.17$ was 0.14 and 0.23, and for $SSB_{2006} = 5,920$ mt the 80% confidence interval was 4,988 mt and 7,110 mt.

The precision of the 2007 stock size estimates are similar between the two formulations. Given the persistent retrospective patterns originating from the VPA BASE RUN formulation and the elimination of the respective patterns for average F and Age 3 and the reduced pattern for SSB from the VPA SPLIT RUN, the VPA SPLIT RUN is selected as the preferred case to use for biological reference point calculations.

5.0 Biological Reference Points

During the SAW/SARC 37 (NEFSC 2003), biological reference points were updated for witch flounder using yield and spawning stock biomass per recruit analyses (Thompson and Bell 1934) and the arithmetic mean of the VPA Age 3 recruitment (NEFSC 2003). The biological reference points from that analysis are:

$$\begin{aligned}SSB_{msy} &= 25,248 \text{ mt}; \\F_{msy} &= F_{40\%} = 0.23; \text{ and} \\MSY &= 4,375 \text{ mt.}\end{aligned}$$

For this assessment, yield and spawning stock per recruit analysis were performed using 5-year averages for partial recruitment, stock weights, catch weights and maturity (Table G.16). Based on yield and SSB per recruit analyses, a proxy of F_{msy} is $F_{40\%}MSP = 0.22$ for both the BASE and SPLIT runs (Table G.17).

Two long-term (100 year) stochastic projections (AGEPRO v3.1.3) were performed to estimate spawning stock biomass and MSY under equilibrium conditions. The same partial recruitment vectors, mean weights at age and maturity vectors used in the yield and SSB per recruit analysis were also used in the projections. A constant F scenario was used ($F = F_{msy} = 0.22$). Estimates of age 3 recruitment used in the projections were derived by re-sampling the cumulative density function based on the empirical observations during 1982 to 2006 (1979 to 2003 year classes) from the BASE RUN and the SPLIT RUN (Table G.16). Fishing mortality was apportioned among landings and discards based on the proportions observed during 2002 – 2006. The proportions of F and M which occurs before spawning equals 0.1667 (March 1); M assumed to be 0.15. Long-term stochastic projections of landings and SSB are given in Figures G.18 and G.19.

BASE RUN

SSBmsy = 12,687 mt
MSY = 2,578 mt

SPLIT RUN

SSBmsy = 10,863 mt
MSY = 2,195 mt

6.0 Summary

Two VPA formulations were performed for witch flounder: a BASE run and SPLIT run where survey tuning indices were split into two series between 1994 and 1995. The precision of stock sizes at age were similar between the two runs. The retrospective patterns observed in previous assessments persist in the BASE run while the retrospective patterns diminish in the SPLIT run. The VPA SPLIT run is selected as the preferred run.

The 2006 witch flounder assessment reveals that discards continue to be a minor component of the total catch. Total catch has declined slightly in recent years and is below the time series average. Fishing mortality has declined substantially since 1996 and is currently at a record low. Spawning stock biomass has shown a declining trend between 1982 and 1996 and an increasing trend until 2003 but remains below the time series average. Age 3 recruitment has averaged 10.9 million fish over the time series; the four most recent year classes (2000 – 2003 year classes) are below average, and the 2001 and 2002 year classes are the smallest in the time series. Based on the VPA SPLIT run, the 2006 fishing mortality is 0.17 and spawning stock biomass is 5,920 mt.

Biological reference points are estimated. Based on yield per recruit analyses, $F_{\text{msy}} = F40\% \text{MSP} = 0.22$. SSBmsy and MSY were estimated using two long-term stochastic projections. Based on the VPA BASE run, SSBmsy = 12,687 mt and MSY = 2,578 mt; based on the VPA SPLIT run, SSBmsy = 10,863 mt and MSY = 2,195 mt.

7.0 Sources of Uncertainty

- Low frequency of samples across market category and quarter results in imprecise mean weights at age and estimates of numbers at age.
- Lack of data to support direct estimates of discards at age requires use of various surrogate survey-based methods.
- The research bottom trawl survey catches very few witch flounder; in many years, the stratified mean number per tow of witch flounder is less than 5 fish. Abundance of witch flounder in the late 1980s and early 1990's may have gone below levels that provide reliable estimates of trends in abundance and biomass

8.0 Acknowledgments

We thank all those who diligently collected data from the commercial fisheries (dock-side and at-sea) and the research vessel surveys. We thank J. Burnett for providing the age determinations used in the assessment. We thank all the members of the Groundfish Assessment Review Meetings for their review and helpful comments.

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Table G1. Witch flounder landings, discards and catch (metric tons, live) by country, 1937-2006 [1937-1959 provisional landings reported in Lange and Lux, 1978; 1960-1963 reported to ICNAF/NAFO (Burnett and Clark, 1983)].

Year	LANDINGS						USA Discards	USA Catch
	USA Subarea 4, 5 & 6	USA Subarea 3	USA Total	CAN	Other	Total		
1937			5000			5000		
1938			3600			3600		
1939			3100			3100		
1940			3000			3000		
1941			2000			2000		
1942			1800			1800		
1943			1000			1000		
1944			1000			1000		
1945			1000			1000		
1946			1500			1500		
1947			1500			1500		
1948			1000			1000		
1949			3600			3600		
1950			3000			3000		
1951			2600			2600		
1952			3700			3700		
1953			4200			4200		
1954			4000			4000		
1955			2400			2400		
1956			2000			2000		
1957			1000			1000		
1958			1000			1000		
1959			1000			1000		
1960	1255		1255			1255		
1961	1022		1022	2		1024		
1962	976		976	1		977		
1963	1226		1226	27	121	1374		
1964	1381		1381	37		1418		
1965	2140		2140	22	502	2664		
1966	2935		2935	68	311	3314		
1967	3370		3370	63	249	3682		
1968	2807		2807	56	191	3054		
1969	2542		2542		1310	3852		
1970	3112		3112	19	130	3261		
1971	3220		3220	35	2860	6115		
1972	2934		2934	13	2568	5515		
1973	2523		2523	10	629	3162		
1974	1839		1839	9	292	2140		
1975	2127		2127	13	217	2357		
1976	1871		1871	5	6	1882		
1977	2469		2469	11	13	2493		
1978	3501		3501	18	6	3525		
1979	2878		2878	17		2895		
1980	3128		3128	18	1	3147		
1981	3442		3442	7		3449		

continued.

Table G.1 continued. Witch flounder landings, discards and catch (metric tons, live).

Year	LANDINGS						USA Catch used in VPA	
	USA Subarea	USA Subarea	USA Total	CAN	Other	Total	USA Discards	
	4, 5 & 6	3						
1982	4906		4906	9		4915	48	4954
1983	6000		6000	45		6045	162	6162
1984	6660		6660	15		6675	100	6760
1985	6130	255	6385	46		6431	61	6191
1986	4610	539	5149	67		5216	25	4635
1987	3450	346	3796	23		3819	47	3497
1988	3262	358	3620	45		3665	60	3322
1989	2068	297	2365	13		2378	76	2144
1990	1465	2	1467	12		1479	96	1561
1991	1777		1777	7		1784	217	1994
1992	2227		2227	7		2234	212	2439
1993	2601		2601	10		2611	224	2825
1994	2670		2670	34		2704	339	3009
1995	2209		2209	11		2220	203	2412
1996	2087		2087	10		2097	207	2294
1997	1772		1772	7		1779	209	1981
1998	1848		1848	10		1858	198	2046
1999	2121		2121	19		2140	277	2398
2000	2439		2439	53		2492	178	2617
2001	3020		3020	32		3052	307	3327
2002	3188		3188	34		3222	225	3413
2003	3124		3124	30		3154	334	3458
2004	2917		2917			2917	309	3226
2005	2652		2652			2652	150	2802
2006	1863		1863			1863	87	1950

Table G2. Summary of USA commercial witch flounder landings (mt), number of length samples (n), number of fish measured (len) and number of age samples (age) by market category and quarter for all gear types, 1981 - 2006. The sampling ratio represents the amount of landings per length sample.

Year	Quarter 1			Quarter 2			Quarter 3			Quarter 4			Total All	Sampling Ratio
	Small	Med.	Large											
1981 mt	260	7	517	269	32	694	242	13	607	230	0	453	3324	
n	.	.	.	.	1	1	.	1	.	1	.	1	5	665
len	.	.	.	101	103	.	89	.	105	.	100	.	498	
age	.	.	.	26	.	25	.	25	.	25	.	25	101	
1982 mt	348	1	726	342	73	886	287	170	739	278	201	669	4720	
n	5	2	6	1	2	2	2	2	6	3	4	2	37	128
len	527	194	626	126	209	216	189	210	514	307	393	189	3700	
age	128	55	150	30	55	50	50	50	150	81	105	50	954	
1983 mt	475	250	910	471	286	1037	298	154	758	257	169	613	5678	
n	5	2	3	5	1	5	8	3	8	6	3	.	49	116
len	680	232	265	685	96	520	1008	123	981	677	344	.	5611	
age	135	30	55	131	16	125	152	0	159	180	75	.	1058	
1984 mt	462	322	1036	513	393	1000	403	248	653	429	286	586	6331	
n	5	9	4	7	1	7	8	1	2	4	2	1	51	124
len	804	1112	400	970	117	775	1045	106	191	615	243	91	6469	
age	154	250	76	186	25	180	210	28	53	105	44	25	1336	
1985 mt	465	377	613	697	453	850	526	291	553	433	310	408	5976	
n	12	1	2	5	4	7	7	7	6	8	2	4	65	92
len	1530	105	229	657	426	698	795	800	684	824	264	349	7361	
age	319	29	50	106	77	153	97	138	113	161	25	29	1297	
1986 mt	384	309	356	654	421	595	375	238	354	312	212	238	4448	
n	6	3	5	5	4	5	4	3	4	5	3	2	49	90
len	662	307	515	558	410	413	302	364	406	416	337	233	4923	
age	123	60	89	106	97	129	63	75	100	87	75	52	1056	
1987 mt	349	211	228	432	317	387	296	203	247	298	203	202	3373	
n	1	1	2	4	2	3	5	5	4	2	3	2	34	69
len	85	145	200	323	228	316	354	583	400	204	261	178	3277	
age	25	25	50	77	47	76	78	113	95	48	64	51	749	
1988 mt	424	304	271	436	393	389	184	176	208	140	140	131	3196	
n	5	4	5	5	5	3	5	4	3	3	4	3	49	65
len	335	407	465	344	544	429	396	359	295	229	402	356	4561	
age	70	89	106	71	110	77	70	100	75	61	95	69	993	
1989 mt	230	174	148	255	264	251	98	145	156	85	107	103	2016	
n	1	2	2	2	2	1	2	2	1	1	2	.	18	112
len	94	201	222	230	236	27	150	206	100	125	202	.	1793	
age	25	50	49	50	46	25	40	51	25	25	47	.	433	

Table G2 continued. Summary of commercial smpling for witch flounder.

Year	Quarter 1			Quarter 2			Quarter 3			Quarter 4			Total All	Sampling Ratio
	Small	Med.	Large											
1990 mt	113	125	107	147	168	147	100	119	129	84	79	85	1403	
n	1	2	3	6	3	1	6	2	2	7	2	.	35	40
len	134	199	199	335	296	100	349	247	145	381	201	.	2586	
age	15	40	45	81	70	25	69	41	50	103	48	.	587	
1991 mt	71	56	58	219	151	167	192	142	184	168	108	121	1637	
n	5	2	3	7	2	1	4	2	3	5	4	3	41	40
len	262	224	401	537	239	125	212	165	249	300	410	274	3398	
age	53	50	80	93	45	25	49	49	52	66	97	58	717	
1992 mt	180	86	82	466	163	174	205	115	138	212	97	116	2034	
n	4	2	2	7	1	2	7	1	1	2	.	1	30	68
len	259	241	185	501	125	235	477	121	117	129	.	46	2436	
age	42	46	52	78	25	25	86	25	25	27	.	23	454	
1993 mt	350	112	110	442	192	161	263	122	150	331	96	106	2435	
n	7	1	.	7	1	1	9	1	5	.	.	.	32	76
len	830	100	.	741	107	100	728	85	499	.	.	.	3190	
age	55	25	.	56	27	26	74	.	73	.	.	.	336	
1994 mt	403	143	98	505	183	154	390	122	117	383	91	80	2669	
n	.	.	.	3	5	6	5	5	1	5	3	4	37	72
len	.	.	.	560	532	749	356	648	105	342	368	407	4067	
age	.	.	.	59	104	134	44	113	26	56	60	82	678	
1995 mt	336	91	77	586	117	100	399	61	70	304	48	40	2229	
n	3	3	3	6	3	5	.	.	.	2	.	1	26	85
len	208	348	347	459	367	517	.	.	.	217	.	94	2557	
age	53	84	89	81	75	135	.	.	.	27	.	25	569	
1996 mt	313	57	36	545	86	60	458	56	44	363	42	28	2088	
n	5	2	3	5	2	1	5	4	4	5	3	3	42	50
len	504	218	292	331	240	127	494	464	468	343	277	348	4106	
age	59	45	78	53	50	26	59	86	101	60	70	69	756	
1997 mt	313	40	25	478	86	41	398	55	27	265	31	16	1775	
n	6	3	3	9	4	3	9	3	1	9	1	1	52	34
len	557	350	351	812	418	309	783	308	107	505	128	50	4678	
age	77	68	70	108	73	77	98	81	20	73	18	23	786	
1998 mt	372	39	19	587	79	31	380	40	20	239	26	14	1846	
n	5	2	1	4	1	1	5	3	1	.	.	.	23	80
len	339	206	128	238	88	135	484	186	100	.	.	.	1904	
age	45	50	19	30	.	29	47	22	.	.	.	.	242	
1999 mt	386	48	19	616	79	31	436	67	30	353	38	18	2121	
n	3	.	.	4	.	.	17	2	3	11	1	.	41	51
len	282	.	.	308	.	.	1110	201	306	775	109	.	3091	
age	15	.	.	62	.	.	143	.	32	91	16	.	359	

Table G2 continued. Summary of commercial sampling for witch flounder.

Year	Quarter 1			Quarter 2			Quarter 3			Quarter 4			Total All	Sampling Ratio
	Small	Med.	Large											
2000 mt	477	53	17	583	93	27	555	89	28	451	50	16	2439	
n	31	2	.	47	.	.	17	1	.	5	5	2	110	22
len	2253	91	.	2445	.	.	994	105	.	308	558	217	6971	
age	393	10	.	463	.	.	224	20	.	67	92	51	1320	
2001 mt	583	71	17	824	99	30	699	98	28	507	50	13	3019	
n	8	4	2	3	3	2	8	2	3	5	3	.	43	70
len	744	422	134	237	352	159	594	209	213	313	232	.	3609	
age	125	64	42	48	48	64	126	34	46	61	49	.	707	
2002 mt	740	79	18	774	103	26	849	114	29	400	45	9	3186	
n	5	1	2	3	5	3	5	2	3	3	2	2	36	89
len	363	121	107	212	518	209	389	150	194	262	226	115	2866	
age	75	16	50	65	73	64	88	34	62	49	30	49	655	
2003 mt	603	70	17	684	108	30	865	125	36	533	43	10	3124	
n	4	6	6	10	5	10	11	6	16	7	7	13	101	31
len	324	423	162	881	482	433	943	531	552	654	632	525	6542	
age	57	93	60	131	64	174	172	91	246	99	120	191	1498	
2004 mt	609	76	16	598	90	23	758	113	30	546	45	13	2917	
n	5	13	23	8	5	8	5	5	2	19	5	15	113	26
len	480	1244	1813	675	549	576	541	356	48	1838	420	83	8623	
age	73	226	505	151	96	169	58	95	10	49	72	.	1504	
2005 mt	603	69	14	639	101	18	618	96	21	433	34	6	2652	
n	15	8	11	10	7	9	8	8	12	9	8	15	120	22
len	727	525	309	798	523	288	542	369	329	512	422	445	5789	
age	78	65	104	117	113	93	130	92	165	92	99	229	1377	
2006 mt	619	67	14	418	52	8	367	46	12	232	24	4	1863	
n	9	6	14	11	5	16	11	5	26	11	5	29	148	13
len	501	538	765	837	433	255	584	268	392	577	444	334	5928	
age	90	114	246	146	118	119	129	75	282	119	106	238	1782	

Table G.3 The number of observed trips, witch flounder discards (in metric tons) and coefficient of variation (CV) by the large-mesh otter trawl, small-mesh otter trawl and northern shrimp trawl fleets, 1982 – 2006.

YEAR	used in VPA									
	Large-mesh Otter Trawl			Small-mesh Otter Trawl			Shrimp Trawl		Total	
	trips	mt	CV	trips	mt	CV	trips	mt	mt	CV
1982		42						6	48	
1983		149						13	162	
1984		89						11	100	
1985		49						12	61	
1986		12						13	25	
1987		26						22	47	
1988		26						34	60	
1989	55	56	0.46	45	2	0.44	36	19	76	0.45
1990	46	55	0.41	22	12	0.92	47	29	96	0.37
1991	72	184	0.42	41	3	0.87	62	29	217	0.41
1992	62	193	0.31	28	1	5.29	110	18	212	0.31
1993	29	215	0.39	11	0	3.41	104	9	224	0.39
1994	25	318	0.50	2	5		98	16	339	0.49
1995	48	159	0.16	34	10	0.25	88	34	203	0.15
1996	23	144	0.56	44	50	0.38	50	14	207	0.43
1997	19	191	0.38	7	5	13.15	28	13	209	0.49
1998	9	117	1.51	1	62			18	198	0.99
1999	32	146	0.53	16	120	0.67		12	277	0.42
2000	93	126	0.24	7	44	0.61		8	178	0.24
2001	139	239	0.17	14	63	0.37		4	307	0.16
2002	205	211	0.18	51	13	0.84		1	225	0.18
2003	372	281	0.12	43	53	0.22	15	0	334	0.11
2004	425	288	0.12	96	20	0.39	12	0	309	0.11
2005	1097	126	0.07	157	24	0.18	17	0	150	0.07
2006	519	72	0.09	48	15	0.34	20	0	87	0.10

Due to small sample sizes in 1994 and 1998 in the small-mesh otter trawl fleet, the boxed values represent an average discard weight of the preceding and following years.

Table G.4. Witch flounder discards at age (thousands of fish) from the large-mesh otter trawl and northern shrimp trawl fleets, 1982 - 2006.

Year	All Discards in Numbers (1000's) at Age											
	0	1	2	3	4	5	6	7	8	9	10	11+
1982	0.030	0.060	1.719	72.590	237.874	87.770	21.102	0.000	0.000	0.000	0.000	0.000
1983	0.000	0.020	4.283	117.310	577.567	487.062	7.822	0.000	0.000	0.000	0.000	0.000
1984	0.000	0.334	0.884	56.013	453.907	194.004	5.286	0.000	0.000	0.000	0.000	0.000
1985	0.000	0.338	3.470	123.580	191.020	91.412	2.437	0.000	0.000	0.000	0.000	0.000
1986	0.000	0.532	3.859	16.649	78.567	75.193	2.745	0.000	0.000	0.000	0.000	0.000
1987	2.084	18.918	79.933	22.250	99.755	145.459	4.060	0.000	0.000	0.000	0.000	0.000
1988	0.417	14.659	130.291	600.271	89.115	88.302	3.567	0.000	0.000	0.000	0.000	0.000
1989	0.737	11.107	52.609	89.660	303.471	104.106	0.000	0.000	0.396	0.000	0.000	0.000
1990	1.187	5.176	116.983	303.232	200.684	200.585	0.000	0.000	0.000	0.000	0.000	0.000
1991	2.958	17.794	78.958	496.264	450.987	348.944	129.780	0.000	0.000	0.000	0.000	0.000
1992	2.706	43.408	136.916	161.856	460.095	273.947	130.037	12.009	0.000	0.000	0.000	0.000
1993	112.060	78.837	108.179	86.473	584.190	395.440	5.872	2.206	0.000	0.000	0.000	0.000
1994	8.058	1368.463	498.455	67.221	439.211	629.888	59.437	119.237	2.287	2.786	0.000	7.859
1995	2.680	49.949	658.585	640.868	354.387	278.294	108.050	2.413	0.993	0.284	0.000	0.000
1996	5.206	32.683	51.477	141.832	327.193	418.024	61.442	0.000	0.000	0.000	0.000	0.000
1997	8.683	74.911	106.806	124.289	485.868	366.753	155.794	5.404	1.367	0.781	0.000	0.248
*1998	49.780	392.321	278.498	220.996	283.455	240.982	70.956	10.156	0.318	0.238	0.000	0.000
*1999	32.110	253.018	188.874	146.512	275.888	340.571	51.780	15.455	1.912	0.804	0.000	0.000
*2000	21.610	169.950	121.192	122.168	291.153	297.891	74.732	17.516	2.878	0.000	0.000	0.000
*2001	12.330	96.960	66.280	65.071	310.455	645.812	176.741	43.068	0.143	0.143	0.000	0.000
*2002	2.320	19.121	15.755	32.539	406.974	471.164	125.103	34.891	5.906	2.781	1.127	1.068
2003	0.000	1.429	6.686	31.990	226.211	585.743	379.425	120.428	23.726	6.433	1.328	1.408
2004	0.000	0.148	9.622	32.951	169.061	476.762	383.720	116.846	31.664	15.111	13.510	7.967
2005	0.000	5.920	14.598	15.318	109.137	196.146	158.955	53.816	9.365	4.596	1.313	0.854
2006	0.000	2.359	15.315	41.319	34.624	60.864	136.757	36.577	9.802	3.726	2.121	1.770

Table G.5. Witch flounder discard mean weight (kg) at age in the large-mesh otter trawl and northern shrimp trawl fleets, 1982 - 2006.

Year	All Discards Mean Weight (kg) at Age											
	0	1	2	3	4	5	6	7	8	9	10	11+
1982	0.000	0.002	0.038	0.048	0.126	0.127	0.181					
1983		0.009	0.038	0.064	0.130	0.158	0.248					
1984		0.017	0.040	0.053	0.141	0.162	0.253					
1985		0.017	0.023	0.128	0.153	0.166	0.231					
1986		0.017	0.026	0.090	0.125	0.173	0.229					
1987	0.006	0.015	0.033	0.081	0.125	0.201	0.232					
1988	0.004	0.006	0.017	0.045	0.142	0.200	0.276					
1989	0.010	0.012	0.032	0.058	0.145	0.225						
1990	0.004	0.010	0.032	0.049	0.134	0.191						
1991	0.004	0.014	0.038	0.057	0.154	0.235	0.239					
1992	0.003	0.007	0.021	0.067	0.178	0.264	0.292					
1993	0.003	0.009	0.022	0.096	0.199	0.235	0.316					
1994	0.005	0.004	0.019	0.083	0.179	0.226	0.364					
1995	0.005	0.007	0.025	0.052	0.151	0.222	0.253	0.473	0.595	0.702		
1996	0.004	0.019	0.031	0.064	0.134	0.208	0.251					
1997	0.004	0.023	0.034	0.065	0.157	0.197	0.245	0.498	0.471	0.702		
*1998	0.003	0.006	0.024	0.061	0.161	0.203	0.222	0.230	0.355	0.370		
*1999	0.003	0.006	0.024	0.067	0.162	0.219	0.283	0.407	0.423	0.495		
*2000	0.003	0.006	0.025	0.070	0.146	0.185	0.253	0.238	0.256			
*2001	0.003	0.006	0.023	0.084	0.166	0.207	0.227	0.257	0.309	0.309		
*2002	0.003	0.007	0.030	0.099	0.172	0.201	0.231	0.259	0.427	0.556	0.566	0.404
2003		0.008	0.039	0.069	0.136	0.195	0.237	0.263	0.317	0.416	0.422	0.681
2004		0.009	0.053	0.099	0.156	0.205	0.241	0.289	0.407	0.527	0.510	0.776
2005		0.020	0.065	0.114	0.171	0.211	0.251	0.299	0.390	0.486	0.504	0.754
2006		0.012	0.058	0.102	0.166	0.203	0.232	0.271	0.343	0.351	0.523	0.694
mean												
2002-2006	0.003	0.011	0.049	0.096	0.160	0.203	0.239	0.276	0.377	0.467	0.505	0.662
1982-2006	0.004	0.011	0.032	0.075	0.152	0.201	0.252	0.317	0.390	0.492	0.505	0.662

Table G.6. Total USA commercial catch [landings + shrimp trawl discards + small-mesh otter trawl discards + large-mesh otter trawl discards] in numbers (thousands of fish) at age of witch flounder, 1982 - 2006.

Year	USA Commercial Catch in Numbers (1000's) at Age											
	Age											
0	1	2	3	4	5	6	7	8	9	10	11+	
1982	0.03	0.06	1.72	190.49	1064.47	1207.67	1475.40	665.20	656.00	399.50	239.40	1578.40
1983	0.00	0.02	4.28	337.11	1346.17	1520.76	1575.12	1590.20	977.80	737.70	510.40	1675.50
1984	0.00	0.33	0.88	146.61	1466.31	2002.70	1739.59	1486.50	1497.50	696.70	375.10	1718.80
1985	0.00	0.34	3.47	123.58	1176.12	2118.21	1936.24	1524.90	1247.90	606.00	400.40	1359.20
1986	0.00	0.53	3.86	22.95	377.07	1516.79	2775.35	1566.90	834.90	412.70	222.80	758.20
1987	2.08	18.92	79.93	22.25	181.26	467.06	1280.06	1574.70	870.90	480.60	252.40	489.40
1988	0.42	14.66	130.29	600.27	139.91	264.30	658.27	1382.70	1154.10	401.50	266.70	597.50
1989	0.74	11.11	52.64	89.71	310.94	153.89	314.51	759.79	883.03	349.85	123.46	348.20
1990	1.19	5.20	117.44	304.41	383.74	777.92	256.60	274.92	472.90	335.23	81.67	178.18
1991	2.96	17.81	79.02	496.63	630.99	1082.62	649.68	235.94	244.73	292.32	313.79	257.96
1992	2.71	43.42	136.96	161.90	969.69	1113.70	1065.84	729.20	201.70	177.93	120.08	377.12
1993	112.07	78.84	108.18	86.48	1006.41	1418.40	923.58	599.43	585.59	218.78	278.54	390.50
1994	8.06	1369.33	498.77	67.26	641.25	2063.02	1348.70	948.08	199.43	543.18	113.75	332.91
1995	2.68	50.03	659.66	641.91	378.69	1042.99	1708.25	852.50	268.88	97.66	269.93	157.10
1996	5.26	33.01	52.00	143.27	376.76	894.70	1338.67	1444.95	265.89	217.66	57.63	114.77
1997	8.69	74.98	106.91	124.41	698.81	895.76	1206.84	1020.84	593.49	84.04	49.86	70.43
1998	50.35	396.81	281.68	223.52	305.00	737.28	1299.16	1611.39	375.07	143.21	15.72	71.10
1999	32.78	258.29	192.81	149.57	470.65	945.62	1473.65	1218.65	781.02	257.33	32.23	55.49
2000	21.76	171.16	122.06	123.04	369.17	563.44	1155.89	1700.99	1014.12	562.08	93.80	236.28
2001	12.44	97.81	66.86	65.64	332.14	1034.71	1117.68	1741.80	1468.35	638.15	431.21	312.29
2002	2.32	19.15	15.78	32.60	577.05	1121.78	1360.71	2146.03	1278.12	643.92	95.39	202.57
2003	0.00	1.44	6.73	32.20	284.89	1110.77	1612.64	1893.78	1569.61	752.42	437.81	350.74
2004	0.00	0.15	9.65	33.04	358.60	1176.53	1609.34	1524.68	1157.43	802.37	327.82	293.84
2005	0.00	5.94	14.65	15.38	184.97	837.19	1868.38	1806.99	831.33	414.93	236.86	133.70
2006	0.00	2.37	15.37	41.47	71.08	239.13	710.98	1561.45	882.44	360.97	135.22	75.07

Table G.7. USA commercial catch mean weight (kg) at age of witch flounder, 1982 - 2006.

Year	USA Commerical Mean Weight (kg) at Age											
	0	1	2	3	4	5	6	7	8	9	10	11+
1982	0.002	0.038	0.152	0.242	0.329	0.421	0.550	0.727	0.886	0.983	1.406	
1983	0.009	0.038	0.149	0.202	0.270	0.409	0.518	0.613	0.795	0.977	1.357	
1984	0.017	0.040	0.151	0.229	0.328	0.421	0.539	0.664	0.817	0.922	1.339	
1985	0.017	0.023	0.128	0.237	0.305	0.429	0.565	0.691	0.842	0.964	1.326	
1986	0.017	0.026	0.089	0.206	0.299	0.408	0.533	0.676	0.853	0.975	1.321	
1987	0.006	0.015	0.033	0.081	0.191	0.298	0.433	0.561	0.686	0.828	0.980	1.303
1988	0.004	0.006	0.017	0.045	0.203	0.311	0.434	0.538	0.668	0.819	0.980	1.326
1989	0.010	0.012	0.032	0.058	0.147	0.263	0.425	0.574	0.682	0.818	0.968	1.358
1990	0.004	0.010	0.032	0.049	0.217	0.289	0.438	0.586	0.688	0.849	1.049	1.454
1991	0.004	0.014	0.038	0.057	0.192	0.327	0.402	0.578	0.702	0.836	0.974	1.420
1992	0.003	0.007	0.021	0.067	0.257	0.354	0.439	0.610	0.739	0.822	0.882	1.243
1993	0.003	0.009	0.022	0.096	0.238	0.328	0.431	0.534	0.666	0.882	1.023	1.335
1994	0.005	0.004	0.019	0.083	0.219	0.317	0.427	0.527	0.690	0.833	0.909	1.264
1995	0.005	0.007	0.025	0.052	0.160	0.328	0.436	0.561	0.690	0.910	0.974	1.243
1996	0.004	0.019	0.031	0.064	0.149	0.286	0.426	0.554	0.708	0.856	0.974	1.232
1997	0.004	0.023	0.034	0.065	0.206	0.291	0.386	0.495	0.628	0.869	1.037	1.291
1998	0.003	0.006	0.024	0.061	0.165	0.289	0.373	0.490	0.585	0.870	0.978	1.206
1999	0.003	0.006	0.024	0.067	0.228	0.305	0.402	0.515	0.584	0.628	0.917	0.872
2000	0.003	0.006	0.025	0.070	0.182	0.251	0.368	0.453	0.534	0.624	0.704	0.915
2001	0.003	0.006	0.023	0.084	0.173	0.250	0.359	0.463	0.550	0.645	0.647	0.840
2002	0.003	0.007	0.030	0.099	0.226	0.284	0.399	0.473	0.552	0.652	0.823	0.938
	0.008	0.039	0.069	0.164	0.251	0.327	0.422	0.504	0.566	0.620	0.809	
2004		0.053	0.099	0.226	0.272	0.338	0.439	0.539	0.611	0.690	0.870	
2005	0.020	0.065	0.114	0.220	0.300	0.361	0.445	0.556	0.632	0.724	0.908	
2006	0.012	0.058	0.102	0.229	0.295	0.345	0.460	0.549	0.652	0.716	0.927	
mean												
2002-2006	0.003	0.012	0.049	0.096	0.213	0.280	0.354	0.448	0.540	0.623	0.715	0.890
1982-2006	0.004	0.011	0.032	0.086	0.204	0.297	0.402	0.519	0.635	0.776	0.896	1.180

Table G.8. Stratified mean number, weight (kg), length (cm), and individual weight (kg) per tow of witch flounder in **NEFSC offshore spring and autumn bottom trawl surveys** in Gulf of Maine-Georges Bank region (strata 22-30,36-40), 1963-2007.

Year	SPRING				AUTUMN			
	Number per tow	Weight per tow	Length per tow	Ave. wt. per tow	Number per tow	Weight per tow	Length per tow	Ave. wt. per tow
1963	-	-	-	-	5.52	3.46	39.7	0.627
1964	-	-	-	-	2.89	2.09	44.2	0.724
1965	-	-	-	-	3.94	2.29	40.6	0.580
1966	-	-	-	-	7.89	4.61	41.2	0.585
1967	-	-	-	-	3.00	1.99	43.7	0.666
1968	4.71	3.27	42.3	0.693	4.82	3.52	44.8	0.731
1969	3.73	2.59	45.3	0.695	5.81	4.21	43.5	0.725
1970	6.39	4.50	44.7	0.705	4.89	3.68	45.0	0.753
1971	2.74	2.04	46.5	0.747	4.32	2.96	42.1	0.686
1972	5.35	4.01	45.8	0.749	3.24	2.42	43.9	0.747
1973	8.20	6.21	44.8	0.758	3.18	2.05	43.6	0.646
1974	6.23	3.62	39.3	0.581	2.38	1.58	41.0	0.666
1975	3.72	2.75	43.9	0.739	1.66	1.03	39.8	0.621
1976	5.50	3.70	42.3	0.673	1.34	0.94	41.9	0.699
1977	4.20	1.96	37.2	0.467	5.05	3.38	42.0	0.669
1978	3.87	2.56	41.7	0.662	4.04	2.94	42.8	0.727
1979	2.91	1.71	38.2	0.587	1.94	1.62	45.2	0.838
1980	8.46	3.89	36.0	0.460	2.62	2.04	43.7	0.777
1981	8.14	4.05	38.0	0.497	3.66	2.19	40.4	0.600
1982	3.64	1.87	37.2	0.513	0.99	0.83	44.7	0.842
1983	6.41	2.74	36.3	0.427	4.72	2.12	36.7	0.448
1984	3.00	1.66	39.9	0.554	4.37	2.33	39.7	0.534
1985	5.18	2.75	40.3	0.531	2.76	1.59	41.9	0.577
1986	2.07	1.35	44.1	0.650	1.59	1.09	43.3	0.683
1987	1.01	0.65	43.4	0.646	0.48	0.37	43.9	0.774
1988	1.43	0.85	42.3	0.590	1.38	0.57	35.2	0.414
1989	1.95	0.74	35.8	0.382	0.89	0.38	31.4	0.423
1990	0.63	0.24	35.2	0.378	2.00	0.40	24.7	0.200
1991	1.68	0.57	31.5	0.341	2.08	0.54	29.2	0.258
1992	1.26	0.48	34.8	0.383	0.94	0.24	29.5	0.254
1993	1.47	0.36	30.3	0.245	5.15	0.54	17.0	0.105
1994	3.13	0.53	27.4	0.170	2.21	0.42	24.9	0.191
1995	1.88	0.47	30.6	0.248	4.74	0.62	25.7	0.132
1996	1.36	0.28	30.5	0.204	5.38	1.02	29.7	0.189
1997	2.22	0.43	31.0	0.195	5.10	0.77	24.9	0.150
1998	4.27	0.77	29.0	0.179	3.70	0.47	24.2	0.127
1999	3.15	0.48	28.1	0.153	5.91	0.88	26.3	0.148
2000	3.45	0.52	27.3	0.151	6.63	1.11	27.1	0.167
2001	4.41	0.75	29.5	0.170	7.94	1.71	32.3	0.216
2002	8.10	1.61	31.4	0.199	4.31	1.06	33.2	0.246
2003	5.20	1.30	34.2	0.250	2.66	0.79	35.4	0.298
2004	3.80	1.08	35.5	0.283	3.82	1.03	33.3	0.271
2005	3.36	0.89	34.6	0.265	1.93	0.38	27.8	0.197
2006	3.09	0.72	32.2	0.235	2.03	0.46	30.5	0.226
2007	2.37	0.58	32.9	0.245	2.74	0.57	31.6	0.208

No significant survey conversion factors for witch flounder.

Table G.9. Stratified mean number per tow at age of witch flounder in NEFSC bottom trawl spring and autumn surveys
 (Strata 22-30, 36-40), 1980 – 2007.

SPRING	AGE														Total	
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14+	
1980	0.000	0.060	0.230	0.950	1.520	0.720	1.200	1.020	0.380	0.400	0.310	0.300	0.120	0.160	1.100	8.460
1981	0.000	0.000	0.050	0.820	0.930	2.000	1.020	0.760	0.670	0.420	0.130	0.200	0.240	0.220	0.900	8.400
1982	0.000	0.044	0.042	0.610	0.484	0.377	0.237	0.609	0.362	0.093	0.259	0.175	0.026	0.033	0.292	3.642
1983	0.000	0.000	0.071	0.531	1.262	1.293	0.541	0.716	0.632	0.475	0.214	0.166	0.075	0.054	0.376	6.407
1984	0.000	0.000	0.103	0.012	0.307	0.778	0.401	0.310	0.202	0.196	0.115	0.173	0.117	0.023	0.266	3.001
1985	0.000	0.000	0.000	0.017	0.459	1.057	1.199	0.908	0.412	0.148	0.149	0.044	0.072	0.027	0.691	5.182
1986	0.000	0.000	0.000	0.000	0.044	0.240	0.529	0.412	0.172	0.194	0.079	0.038	0.063	0.055	0.248	2.073
1987	0.000	0.000	0.000	0.000	0.059	0.114	0.133	0.259	0.185	0.009	0.061	0.023	0.000	0.000	0.163	1.007
1988	0.000	0.023	0.023	0.062	0.000	0.072	0.300	0.379	0.239	0.137	0.086	0.084	0.029	0.000	0.000	1.434
1989	0.000	0.023	0.013	0.036	1.004	0.105	0.073	0.081	0.327	0.081	0.015	0.056	0.056	0.019	0.056	1.945
1990	0.000	0.008	0.000	0.038	0.091	0.319	0.000	0.042	0.009	0.050	0.018	0.009	0.011	0.000	0.030	0.626
1991	0.000	0.042	0.000	0.781	0.108	0.087	0.209	0.033	0.101	0.083	0.138	0.018	0.022	0.000	0.064	1.684
1992	0.000	0.054	0.009	0.187	0.373	0.085	0.111	0.152	0.045	0.149	0.015	0.016	0.046	0.000	0.019	1.260
1993	0.000	0.149	0.112	0.137	0.472	0.320	0.058	0.085	0.000	0.015	0.015	0.000	0.068	0.000	0.037	1.469
1994	0.000	0.107	0.698	0.541	0.644	0.810	0.164	0.027	0.028	0.070	0.008	0.000	0.000	0.016	0.016	3.129
1995	0.000	0.041	0.120	0.581	0.316	0.179	0.312	0.116	0.110	0.042	0.000	0.038	0.028	0.000	0.000	1.883
1996	0.000	0.017	0.036	0.244	0.394	0.346	0.218	0.073	0.000	0.000	0.000	0.032	0.000	0.000	0.000	1.359
1997	0.000	0.072	0.066	0.152	0.693	0.617	0.437	0.084	0.083	0.014	0.000	0.000	0.000	0.000	0.000	2.219
1998	0.000	0.112	1.079	0.712	0.388	0.798	0.713	0.214	0.154	0.076	0.000	0.000	0.000	0.028	0.000	4.274
1999	0.000	0.106	0.376	0.974	0.797	0.482	0.164	0.182	0.031	0.014	0.023	0.000	0.000	0.000	0.000	3.149
2000	0.000	0.007	0.250	1.194	0.692	0.660	0.239	0.253	0.116	0.000	0.035	0.000	0.000	0.000	0.000	3.446
2001	0.000	0.105	0.099	0.713	1.476	1.020	0.401	0.293	0.163	0.113	0.028	0.000	0.000	0.000	0.000	4.409
2002	0.000	0.023	0.060	0.897	2.627	2.263	0.822	0.683	0.351	0.192	0.103	0.014	0.000	0.029	0.037	8.101
2003	0.000	0.000	0.000	0.150	0.808	1.646	1.017	0.869	0.387	0.197	0.046	0.060	0.000	0.016	0.009	5.204
2004	0.000	0.009	0.060	0.074	0.428	0.648	0.809	0.883	0.368	0.158	0.161	0.135	0.000	0.000	0.067	3.799
2005	0.000	0.011	0.160	0.146	0.220	0.737	0.760	0.574	0.383	0.245	0.086	0.018	0.000	0.021	0.000	3.362
2006	0.000	0.043	0.460	0.347	0.138	0.207	0.683	0.568	0.410	0.145	0.069	0.015	0.000	0.000	0.000	3.087
2007	0.000	0.000	0.178	0.571	0.263	0.241	0.228	0.546	0.154	0.158	0.000	0.031	0.000	0.000	0.000	2.370

TableG.9 continued. Stratified mean number per tow at age of witch flounder.

AUTUMN	AGE														Total	
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14+	
1980	0.040	0.000	0.020	0.000	0.200	0.260	0.280	0.360	0.170	0.150	0.270	0.040	0.160	0.120	0.570	2.620
1981	0.030	0.070	0.030	0.240	0.440	0.610	0.460	0.270	0.260	0.180	0.210	0.170	0.040	0.130	0.480	3.660
1982	0.020	0.000	0.000	0.058	0.013	0.027	0.076	0.241	0.132	0.015	0.027	0.032	0.009	0.039	0.301	0.991
1983	0.000	0.008	0.011	0.507	1.596	0.758	0.548	0.444	0.084	0.137	0.073	0.114	0.025	0.000	0.415	4.718
1984	0.000	0.000	0.000	0.093	0.943	0.991	0.605	0.535	0.310	0.149	0.126	0.073	0.041	0.132	0.375	4.373
1985	0.000	0.000	0.009	0.059	0.076	0.610	0.684	0.482	0.270	0.103	0.122	0.029	0.015	0.089	0.217	2.763
1986	0.009	0.000	0.000	0.000	0.051	0.266	0.353	0.309	0.160	0.112	0.009	0.010	0.021	0.052	0.237	1.590
1987	0.000	0.000	0.023	0.000	0.011	0.023	0.046	0.192	0.071	0.000	0.009	0.000	0.000	0.023	0.085	0.482
1988	0.000	0.007	0.000	0.725	0.055	0.012	0.036	0.215	0.048	0.046	0.045	0.079	0.011	0.043	0.055	1.376
1989	0.174	0.018	0.018	0.082	0.301	0.009	0.021	0.017	0.084	0.078	0.024	0.000	0.026	0.000	0.037	0.888
1990	0.481	0.088	0.137	0.380	0.507	0.219	0.024	0.023	0.023	0.025	0.000	0.000	0.009	0.055	0.034	2.005
1991	0.224	0.021	0.177	0.661	0.329	0.290	0.145	0.067	0.059	0.030	0.052	0.028	0.000	0.000	0.000	2.083
1992	0.097	0.029	0.109	0.259	0.224	0.054	0.061	0.000	0.000	0.019	0.009	0.019	0.000	0.019	0.042	0.940
1993	2.541	0.672	0.154	0.544	0.777	0.219	0.058	0.022	0.081	0.000	0.019	0.042	0.000	0.011	0.014	5.154
1994	0.432	0.156	0.287	0.532	0.165	0.395	0.037	0.106	0.000	0.043	0.009	0.000	0.005	0.000	0.042	2.209
1995	0.512	0.203	0.764	1.624	0.858	0.472	0.229	0.000	0.000	0.011	0.054	0.000	0.000	0.000	0.009	4.736
1996	0.232	0.092	0.261	0.785	1.988	1.386	0.441	0.066	0.065	0.037	0.000	0.033	0.000	0.000	0.000	5.384
1997	0.892	0.339	0.979	0.522	0.871	0.770	0.383	0.329	0.000	0.000	0.000	0.000	0.020	0.000	0.000	5.105
1998	0.639	0.082	0.520	1.363	0.465	0.303	0.165	0.110	0.043	0.012	0.000	0.000	0.000	0.000	0.000	3.701
1999	0.323	0.521	1.178	1.514	1.044	0.600	0.364	0.275	0.050	0.037	0.009	0.000	0.000	0.000	0.000	5.915
2000	0.943	0.096	0.719	1.408	1.746	0.674	0.589	0.229	0.152	0.049	0.000	0.000	0.026	0.000	0.000	6.630
2001	0.000	0.039	0.210	0.952	3.156	1.886	0.813	0.612	0.159	0.058	0.056	0.000	0.000	0.000	0.000	7.940
2002	0.000	0.000	0.275	0.431	1.475	0.997	0.532	0.331	0.148	0.071	0.000	0.046	0.005	0.000	0.000	4.311
2003	0.018	0.000	0.038	0.075	0.307	0.580	0.770	0.315	0.129	0.222	0.083	0.021	0.046	0.019	0.038	2.660
2004	0.276	0.072	0.014	0.086	0.453	0.987	0.826	0.498	0.355	0.054	0.105	0.072	0.000	0.000	0.019	3.816
2005	0.132	0.635	0.087	0.023	0.131	0.181	0.269	0.340	0.055	0.052	0.012	0.000	0.000	0.016	0.000	1.933
2006	0.066	0.103	0.540	0.322	0.046	0.104	0.298	0.286	0.138	0.071	0.042	0.014	0.000	0.000	0.000	2.030
2007																

Table G.10. Stratified mean number, weight (kg),length (cm) per tow of witch flounder in **Massachusetts Division of Marine Fisheries inshore spring and autumn surveys** in the Cape Cod Bay and Mass. Bay region (Regions 4 and 5), 1978-2007.

Year	SPRING				AUTUMN			
	Number per tow	Weight per tow	Length per tow	Avg. wt. per tow	Number per tow	Weight per tow	Length per tow	Avg. wt. per tow
1978	2.38	1.67	44.6	0.699	1.38	1.26	46.4	0.908
1979	1.26	1.32	48.3	1.046	1.52	1.08	42.9	0.708
1980	1.00	0.93	44.0	0.932	1.15	1.12	46.5	0.966
1981	2.44	1.83	40.2	0.747	0.39	0.23	41.2	0.589
1982	0.65	0.47	44.2	0.726	1.24	0.64	37.7	0.511
1983	1.97	1.02	36.8	0.519	2.22	1.46	44.6	0.658
1984	1.18	0.76	40.8	0.645	0.55	0.37	43.6	0.674
1985	1.01	0.73	43.4	0.720	0.76	0.50	43.6	0.655
1986	0.70	0.65	47.6	0.934	0.27	0.24	46.4	0.893
1987	0.88	0.73	45.1	0.821	0.19	0.13	44.6	0.713
1988	0.24	0.20	45.6	0.837	0.28	0.16	39.5	0.579
1989	0.13	0.05	34.9	0.369	0.13	0.06	38.1	0.491
1990	0.21	0.17	44.2	0.809	0.07	0.03	36.8	0.436
1991	0.11	0.04	34.1	0.393	0.35	0.21	41.1	0.602
1992	0.20	0.12	40.2	0.583	0.45	0.25	40.7	0.557
1993	0.03	0.01	33.0	0.200	0.30	0.15	40.9	0.500
1994	0.00	0.00	-	-	0.38	0.12	31.0	0.321
1995	0.10	0.06	36.0	0.613	2.41	0.41	26.7	0.172
1996	0.02	<0.01	21.0	0.100	0.04	0.01	40.0	0.400
1997	0.05	0.01	31.5	0.250	0.51	0.15	36.0	0.300
1998	0.00	0.00	-	-	0.25	0.08	35.2	0.332
1999	0.02	<0.01	11.0	0.000	0.67	0.17	33.7	0.251
2000	1.15	0.10	23.5	0.089	0.92	0.24	31.6	0.266
2001	0.07	0.02	33.0	0.250	0.43	0.12	33.2	0.275
2002	0.11	0.03	33.4	0.253	2.21	0.70	36.5	0.317
2003	0.19	0.04	30.2	0.217	1.19	0.53	39.8	0.445
2004	0.00	0.00	-	-	0.31	0.13	40.5	0.432
2005	0.05	0.03	45.5	0.675	0.51	0.19	37.8	0.369
2006	0.16	0.08	40.9	0.500	0.37	0.10	33.0	0.265
2007	0.46	0.13	34.6	0.286	0.51	0.15	36.8	0.295

Table G.11. Stratified mean number, weight (kg), length (cm), and individual weight (kg) per tow of witch flounder in the **ASMFC summer shrimp surveys** in the Gulf of Maine (strata set 1,3,6,8), 1984 - 2007.

Year	Number per tow	Weight per tow	Length per tow	Ave. wt. per tow
1984	4.68	1.60	33.9	0.341
1985	6.19	2.52	36.0	0.408
1986	2.05	0.74	35.9	0.362
1987	4.87	1.50	26.5	0.307
1988	2.53	0.60	25.8	0.238
1989	2.92	0.31	22.8	0.105
1990	6.66	1.02	24.5	0.154
1991	14.94	1.20	19.6	0.080
1992	24.28	1.91	20.5	0.079
1993	21.42	0.50	12.8	0.023
1994	36.36	2.20	19.1	0.061
1995	17.95	1.48	22.6	0.082
1996	15.45	1.95	25.2	0.126
1997	23.19	1.42	19.1	0.061
1998	7.35	0.52	21.9	0.071
1999	110.07	5.93	18.7	0.054
2000	32.43	3.09	24.2	0.095
2001	41.52	5.57	27.2	0.134
2002	45.25	7.05	28.8	0.156
2003	24.06	4.46	30.6	0.185
2004	8.75	1.79	31.3	0.205
2005	19.77	2.00	21.6	0.101
2006	29.98	2.72	22.6	0.091
2007	23.10	2.49	25.1	0.108

Table G.12. Parameter estimates (with associated statistics) and estimates of terminal F from ADAPT VPA formulations for witch flounder, stock size (N) in '000 of fish.

	GARM 2005 BASE RUN	GARM 2008 BASE RUN	GARM 2008 SPLIT RUN
Software	NFT 231	NFT VPA 2.7.7	NFT VPA 2.7.7
CAA	1982-2004 3-11+	1982-2006 3-11+	1982-2006 3-11+
Est.Ages	3-10	3-10	3-10
NMFS-s	3-11+	3-11+	3-11+
NMFS-a	3-11+	3-11+	3-11+
M.S.R.	0.811	0.838	0.699
N3 (cv)	3,902 (.65)	42,333 (.66)	17,353 (.62)
N4 (cv)	4,053 (.46)	9,745 (.47)	4,858 (.44)
N5 (cv)	9,206 (.39)	1,963 (.39)	1,001 (.38)
N6 (cv)	14,614 (.35)	2,725 (.36)	1,382 (.36)
N7 (cv)	19,943 (.32)	5,741 (.34)	3,006 (.36)
N8 (cv)	17,315 (.30)	5,001 (.38)	2,427 (.44)
N9 (cv)	8,815 (.27)	7,810 (.29)	3,480 (.33)
N10 (cv)	2,245 (.37)	7,270 (.24)	2,294 (.35)
Age 3 in T+1 (>000s)	3,902	42,334	17,354
F 1	-	-	-
F 2	-	-	-
F 3	0.006	0.004	0.008
F 4	0.032	0.033	0.064
F 5	0.066	0.078	0.149
F 6	0.069	0.109	0.198
F 7	0.077	0.253	0.466
F 8	0.114	0.100	0.211
F 9	0.284	0.045	0.136
F10	0.199	0.072	0.173
F11+	0.199	0.072	0.173
Ave F 8-9	0.199	0.072	0.173
SSB ('000 mt)	21,175	13,240	5,921

SPLIT survey indices are: 1982-1994 and 1995 -2006.

Table G.13. Summary of witch flounder catch (mt), spawning stock biomass (mt), fully recruited fishing mortality, and recruitment (age 3, millions fish) and year class from **VPA BASE RUN**, 1982 to 2006.

Year	Catch (mt)	SSB (mt)	Avg F8-9	Recuits Age 3	Year Class
1982	4,954	16,901	0.26	15.407	1979
1983	6,162	13,439	0.50	17.703	1980
1984	6,760	11,543	0.63	16.359	1981
1985	6,191	10,431	0.68	7.661	1982
1986	4,635	9,546	0.50	5.429	1983
1987	3,497	8,943	0.60	3.133	1984
1988	3,322	8,304	0.70	9.285	1985
1989	2,201	7,348	0.44	6.064	1986
1990	1,649	6,322	0.25	7.530	1987
1991	1,872	6,940	0.25	8.646	1988
1992	2,398	7,040	0.23	12.130	1989
1993	2,977	5,821	0.45	8.898	1990
1994	3,087	4,339	0.60	13.600	1991
1995	2,402	4,061	0.63	11.960	1992
1996	2,341	3,906	1.13	17.639	1993
1997	2,071	4,262	1.06	16.176	1994
1998	2,134	5,479	0.62	21.010	1995
1999	2,334	6,798	0.49	17.702	1996
2000	2,554	8,215	0.50	31.509	1997
2001	3,243	9,171	0.71	29.878	1998
2002	3,467	10,359	0.35	18.890	1999
2003	3,505	11,857	0.36	13.359	2000
2004	3,150	12,283	0.28	4.888	2001
2005	2,804	14,576	0.13	2.756	2002
2006	1,953	13,240	0.07	11.367	2003
min	1,649	3,906	0.07	2.756	
max	6,760	16,901	1.13	31.509	
mean	3,267	8,845	0.50	13.159	
geomean				11.127	
median				12.130	

Table G.14. Summary of witch flounder catch (mt), spawning stock biomass (mt), fully recruited fishing mortality, and recruitment (age 3, millions fish) and year class from **VPA SPLIT RUN**, 1982 to 2006.

Year	Catch (mt)	SSB (mt)	Avg F8-9	Recuits Age 3	Year Class
1982	4,954	16,901	0.26	15.406	1979
1983	6,162	13,439	0.50	17.703	1980
1984	6,760	11,543	0.63	16.357	1981
1985	6,191	10,431	0.68	7.660	1982
1986	4,635	9,546	0.50	5.427	1983
1987	3,497	8,943	0.60	3.132	1984
1988	3,322	8,304	0.70	9.282	1985
1989	2,201	7,346	0.44	6.063	1986
1990	1,649	6,320	0.25	7.528	1987
1991	1,872	6,936	0.25	8.643	1988
1992	2,398	7,037	0.23	12.108	1989
1993	2,977	5,816	0.45	8.849	1990
1994	3,087	4,332	0.60	13.140	1991
1995	2,402	4,044	0.63	11.761	1992
1996	2,341	3,851	1.14	16.152	1993
1997	2,071	4,141	1.08	14.546	1994
1998	2,134	5,202	0.64	16.594	1995
1999	2,334	6,246	0.52	14.316	1996
2000	2,554	7,204	0.54	17.274	1997
2001	3,243	7,441	0.83	19.216	1998
2002	3,467	7,486	0.46	13.425	1999
2003	3,505	7,536	0.55	8.372	2000
2004	3,150	6,819	0.53	2.781	2001
2005	2,804	7,112	0.29	1.457	2002
2006	1,953	5,920	0.17	5.688	2003
min	1,649	3851	0.17	1.457	
max	6,760	16901	1.14	19.216	
mean	3,267	7595.84	0.54	10.915	
geommean				9.314	
median				11.761	

Table G.15. Estimates of beginning year stock size ('000 of fish), instantaneous fishing mortality and spawning stock biomass (mt) for witch flounder estimated from the virtual population analysis, 1982-2006 **VPA SPLIT RUN**.

JAN-1 Population Numbers

AGE	1982	1983	1984	1985	1986
3	15406.	17703.	16357.	7660.	5427.
4	12175.	13084.	14925.	13943.	6479.
5	9564.	9494.	10015.	11489.	10912.
6	7830.	7114.	6765.	6770.	7930.
7	4289.	5376.	4668.	4217.	4040.
8	2752.	3077.	3160.	2647.	2225.
9	2102.	1763.	1747.	1344.	1132.
10	1101.	1440.	839.	862.	599.
11	7260.	4728.	3844.	2926.	2040.
<hr/>					
Total	62480.	63779.	62319.	51857.	40784.
AGE	1987	1988	1989	1990	1991
3	3132.	9282.	6063.	7528.	8643.
4	4650.	2675.	7433.	5135.	6197.
5	5227.	3834.	2173.	6109.	4065.
6	7989.	4066.	3055.	1728.	4539.
7	4268.	5692.	2891.	2339.	1250.
8	2035.	2223.	3623.	1787.	1758.
9	1146.	950.	854.	2303.	1102.
10	594.	544.	449.	413.	1672.
11	1152.	1219.	1265.	902.	1374.
<hr/>					
Total	30192.	30486.	27805.	28244.	30600.
AGE	1992	1993	1994	1995	1996
3	12108.	8849.	13140.	11761.	16152.
4	6979.	10271.	7536.	11247.	9528.
5	4750.	5110.	7909.	5893.	9330.
6	2499.	3060.	3089.	4903.	4108.
7	3306.	1171.	1782.	1419.	2646.
8	858.	2172.	457.	664.	441.
9	1287.	552.	1329.	210.	324.
10	679.	943.	274.	644.	91.
11	2131.	1322.	801.	375.	181.
<hr/>					
Total	34596.	33450.	36316.	37115.	42801.

AGE	1997	1998	1999	2000	2001
3	14546.	16594.	14316.	17274.	19216.
4	13770.	12404.	14075.	12184.	14754.
5	7852.	11204.	10394.	11679.	10144.
6	7202.	5929.	8961.	8071.	9530.
7	2302.	5083.	3903.	6350.	5877.
8	952.	1042.	2889.	2236.	3896.
9	136.	277.	552.	1766.	992.
10	80.	40.	107.	238.	1002.
11	113.	181.	184.	600.	725.
<hr/>					
Total	46952.	52755.	55381.	60397.	66137.
AGE	2002	2003	2004	2005	2006
3	13425.	8372.	2781.	1457.	5688.
4	16479.	11525.	7176.	2363.	1240.
5	12391.	13649.	9656.	5844.	1863.
6	7774.	9627.	10719.	7222.	4256.
7	7168.	5433.	6795.	7738.	4491.
8	3452.	4190.	2931.	4440.	4991.
9	2001.	1794.	2161.	1457.	3053.
10	271.	1128.	852.	1121.	871.
11	575.	904.	763.	633.	507.
<hr/>					
Total	63535.	56622.	43834.	32276.	26961.
AGE	2007				
3	17354.				
4	4858.				
5	1001.				
6	1382.				
7	3006.				
8	2427.				
9	3480.				
10	2294.				
11	998.				
<hr/>					
Total	36799.				

Fishing Mortality Calculated

AGE	1982	1983	1984	1985	1986
3	0.0134	0.0207	0.0097	0.0175	0.0046
4	0.0988	0.1172	0.1117	0.0951	0.0647
5	0.1459	0.1889	0.2417	0.2207	0.1618
6	0.2261	0.2713	0.3227	0.3661	0.4695
7	0.1823	0.3813	0.4172	0.4895	0.5359
8	0.2953	0.4162	0.7051	0.6997	0.5134
9	0.2282	0.5929	0.5562	0.6572	0.4947
10	0.2657	0.4770	0.6495	0.6852	0.5071
11	0.2657	0.4770	0.6495	0.6852	0.5071
AGE	1987	1988	1989	1990	1991
3	0.0077	0.0721	0.0161	0.0445	0.0638
4	0.0429	0.0579	0.0461	0.0838	0.1160
5	0.1010	0.0771	0.0793	0.1472	0.3364
6	0.1889	0.1910	0.1173	0.1739	0.1670
7	0.5022	0.3019	0.3310	0.1351	0.2266
8	0.6114	0.8063	0.3031	0.3337	0.1620
9	0.5948	0.6008	0.5759	0.1701	0.3348
10	0.6054	0.7402	0.3498	0.2384	0.2251
11	0.6054	0.7402	0.3498	0.2384	0.2251
AGE	1992	1993	1994	1995	1996
3	0.0145	0.0106	0.0055	0.0605	0.0096
4	0.1617	0.1113	0.0960	0.0369	0.0435
5	0.2898	0.3533	0.3282	0.2108	0.1088
6	0.6085	0.3908	0.6283	0.4668	0.4293
7	0.2702	0.7900	0.8373	1.0193	0.8718
8	0.2909	0.3413	0.6274	0.5676	1.0267
9	0.1608	0.5517	0.5747	0.6856	1.2475
10	0.2108	0.3805	0.5879	0.5947	1.1144
11	0.2108	0.3805	0.5879	0.5947	1.1144
AGE	1997	1998	1999	2000	2001
3	0.0093	0.0146	0.0113	0.0077	0.0037
4	0.0562	0.0268	0.0367	0.0332	0.0245
5	0.1308	0.0734	0.1030	0.0533	0.1162
6	0.1985	0.2681	0.1944	0.1671	0.1348
7	0.6422	0.4150	0.4072	0.3386	0.3822
8	1.0855	0.4864	0.3423	0.6625	0.5163
9	1.0719	0.8021	0.6895	0.4170	1.1491
10	1.0838	0.5449	0.3905	0.5467	0.6163
11	1.0838	0.5449	0.3905	0.5467	0.6163

Fishing Mortality Calculated

AGE	2002	2003	2004	2005	2006
3	0.0026	0.0042	0.0129	0.0114	0.0079
4	0.0384	0.0270	0.0553	0.0879	0.0637
5	0.1024	0.0916	0.1404	0.1672	0.1485
6	0.2083	0.1984	0.1759	0.3250	0.1978
7	0.3869	0.4671	0.2755	0.2885	0.4656
8	0.5046	0.5122	0.5488	0.2245	0.2106
9	0.4228	0.5948	0.5064	0.3642	0.1359
10	0.4738	0.5363	0.5306	0.2572	0.1733
11	0.4738	0.5363	0.5306	0.2572	0.1733

Average Fishing Mortality For Ages 8-9

Year	Average F	N Weighted	Biomass Wtd	Catch Wtd
1982	0.2618	0.2663	0.2631	0.2699
1983	0.5045	0.4806	0.4919	0.4922
1984	0.6306	0.6521	0.6455	0.6578
1985	0.6784	0.6854	0.6834	0.6858
1986	0.5041	0.5071	0.5062	0.5072
1987	0.6031	0.6054	0.6046	0.6055
1988	0.7035	0.7447	0.7357	0.7532
1989	0.4395	0.3552	0.3641	0.3805
1990	0.2519	0.2416	0.2340	0.2659
1991	0.2484	0.2286	0.2355	0.2561
1992	0.2258	0.2128	0.2082	0.2299
1993	0.4465	0.3839	0.3925	0.3985
1994	0.6011	0.5882	0.5863	0.5889
1995	0.6266	0.5960	0.6023	0.5990
1996	1.1371	1.1202	1.1311	1.1261
1997	1.0787	1.0838	1.0833	1.0838
1998	0.6442	0.5527	0.5708	0.5737
1999	0.5159	0.3980	0.4041	0.4284
2000	0.5398	0.5542	0.5456	0.5750
2001	0.8327	0.6448	0.6622	0.7080
2002	0.4637	0.4745	0.4713	0.4771
2003	0.5535	0.5370	0.5394	0.5390
2004	0.5276	0.5308	0.5292	0.5314
2005	0.2943	0.2590	0.2635	0.2710
2006	0.1733	0.1823	0.1787	0.1889

Spawning Stock Biomass

AGE	1982	1983	1984	1985	1986
3	20.	21.	38.	8.	6.
4	107.	132.	185.	127.	91.
5	376.	459.	580.	685.	993.
6	1116.	1241.	1244.	1584.	1918.
7	1543.	1884.	1715.	1719.	1637.
8	1634.	1544.	1559.	1388.	1219.
9	1632.	1172.	1088.	878.	780.
10	949.	1207.	629.	666.	487.
11	9524.	5779.	4505.	3376.	2415.
Total	16903.	13438.	11541.	10431.	9546.
AGE	1987	1988	1989	1990	1991
3	12.	31.	16.	13.	16.
4	176.	142.	187.	111.	98.
5	845.	702.	329.	551.	379.
6	2472.	1299.	967.	406.	939.
7	1795.	2523.	1305.	1002.	496.
8	1084.	1161.	2035.	1005.	1006.
9	757.	629.	560.	1644.	755.
10	479.	423.	367.	359.	1414.
11	1323.	1394.	1580.	1229.	1833.
Total	8943.	8302.	7346.	6320.	6937.
AGE	1992	1993	1994	1995	1996
3	25.	22.	31.	10.	11.
4	136.	161.	136.	163.	97.
5	472.	477.	682.	625.	860.
6	584.	710.	650.	1283.	1157.
7	1358.	422.	619.	543.	1053.
8	500.	1224.	234.	352.	226.
9	919.	392.	868.	145.	197.
10	549.	792.	217.	512.	69.
11	2494.	1616.	895.	411.	181.
Total	7038.	5817.	4332.	4044.	3853.

Spawning Stock Biomass (continued)

AGE	1997	1998	1999	2000	2001
3	6.	20.	23.	37.	58.
4	107.	162.	225.	183.	236.
5	577.	1001.	805.	891.	683.
6	1829.	1294.	1932.	1513.	1582.
7	898.	1831.	1372.	2048.	1754.
8	457.	494.	1367.	952.	1583.
9	87.	173.	288.	951.	455.
10	61.	33.	87.	140.	554.
11	119.	194.	147.	489.	536.
Total	4142.	5203.	6245.	7204.	7442.

AGE	2002	2003	2004	2005	2006
3	81.	28.	20.	14.	36.
4	374.	242.	165.	74.	35.
5	843.	968.	622.	505.	131.
6	1226.	1356.	1449.	1087.	568.
7	1945.	1368.	1583.	1897.	991.
8	1346.	1502.	983.	1648.	1719.
9	1013.	806.	957.	695.	1490.
10	172.	614.	447.	655.	505.
11	486.	652.	593.	537.	445.
Total	7485.	7537.	6817.	7112.	5921.

Table G.16. Witch flounder input vectors for biological reference points for yield and spawning biomass per recruit analyses and long-term stochastic projections.

BASE RUN

Age	Partial recruitment	Sel. on		Mean	Mean	Maturity
		M	Stock wts	Catch wts	SpStock wts	
3	0.012	1	0.06524	0.09649	0.06524	0.06
4	0.085	1	0.13986	0.21286	0.13986	0.16
5	0.258	1	0.23726	0.28027	0.23726	0.34
6	0.427	1	0.30938	0.35405	0.30938	0.58
7	0.74	1	0.39932	0.44782	0.39932	0.79
8	1	1	0.49180	0.54012	0.49180	0.91
9	1	1	0.57970	0.62257	0.57970	0.96
10	1	1	0.66542	0.71465	0.66542	0.99
11+	1	1	0.89040	0.89043	0.89040	1.00

SPLIT RUN

Age	Partial recruitment	Sel. on		Mean	Mean	Maturity
		M	Stock wts	Catch wts	SpStock wts	
3	0.0117	1	0.06524	0.09649	0.06524	0.06
4	0.0854	1	0.13986	0.21286	0.13986	0.16
5	0.2480	1	0.23726	0.28027	0.23726	0.34
6	0.4107	1	0.30938	0.35405	0.30938	0.58
7	0.7258	1	0.39932	0.44782	0.39932	0.79
8	1.0000	1	0.49180	0.54012	0.49180	0.91
9	1.0000	1	0.57970	0.62257	0.57970	0.96
10	1.0000	1	0.66542	0.71465	0.66542	0.99
11+	1.0000	1	0.89040	0.89043	0.89040	1.00

BASE RUN

year Age - 3 ('000 fish)

1982	15,407
1983	17,703
1984	16,359
1985	7,661
1986	5,429
1987	3,133
1988	9,285
1989	6,064
1990	7,530
1991	8,646
1992	12,130
1993	8,898
1994	13,600
1995	11,960
1996	17,639
1997	16,176
1998	21,010
1999	17,702
2000	31,509
2001	29,878
2002	18,890
2003	13,359
2004	4,888
2005	2,756
2006	11,367

SPLIT RUN

year Age - 3 ('000 fish)

1982	15,406
1983	17,703
1984	16,357
1985	7,660
1986	5,427
1987	3,132
1988	9,282
1989	6,063
1990	7,528
1991	8,643
1992	12,108
1993	8,849
1994	13,140
1995	11,761
1996	16,152
1997	14,546
1998	16,594
1999	14,316
2000	17,274
2001	19,216
2002	13,425
2003	8,372
2004	2,781
2005	1,457
2006	5,688

Table G.17. Witch flounder yield and spawning stock biomass per recruit results and corresponding biological reference points.

For SARC37/GARM 2005, the Fmsy, SSBmsy and MSY were based on yield and spawning stock biomass per recruit and mean 3 age recruitment.

For GARM2008, the Fmsy = F40% MSP is based on yield per recruit analyses, while the SSBmsy and MSY estimates are based on long-term stochastic projections using the VPA BASE RUN and the VPA SPLIT RUN. (*Note: mean age 3 recruitment values are not used in the calculations of GARM2008 SSBmsy and MSY estimates*).

	Fmsy F40%	Y/R (kg)	SSB/R (kg)	Mean Age 3 Recruitment (fish,millions)	SSBmsy (mt)	MSY (mt)
SARC 37/GARM2005	0.23	0.2232	1.2882	19.6	25,248	4,375
GARM 2008						
BASE RUN	0.22	0.1982	0.9890	(13.2)	12,687	2,578
SPLIT RUN	0.22	0.1987	0.9889	(10.9)	10,863	2,195

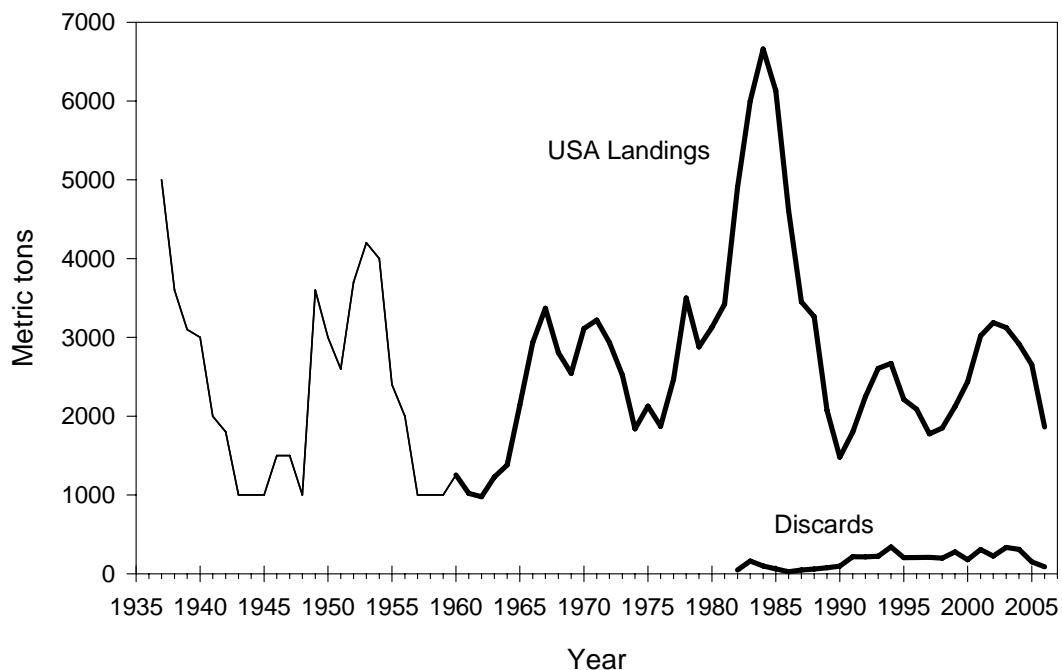


Figure G.1. Historical USA witch flounder landings (mt), excluding USA landings from the Grand Banks in the mid-1980's. The thin line represents provisional landings data taken from Lange and Lux (1978). Discards are from the northern shrimp, small-mesh (<5.5 inch) otter trawl and large-mesh (>5.5 inch) otter trawl fisheries.

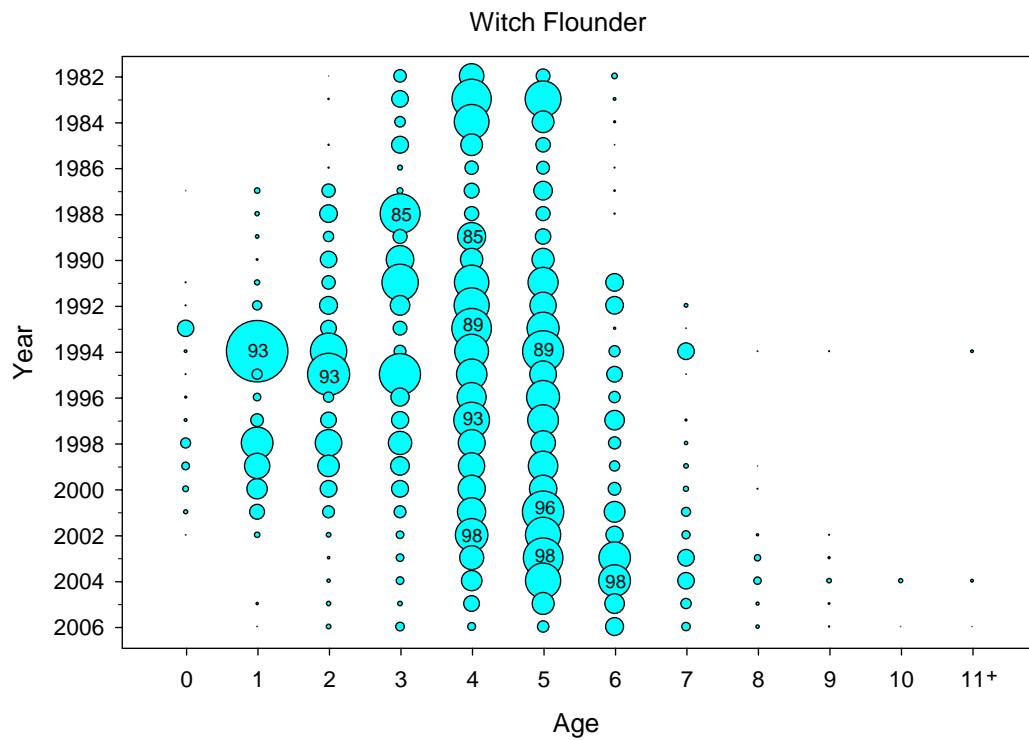


Figure G.2. Witch flounder discards at age (in numbers) from the large-mesh otter trawl and northern shrimp trawl fleets, 1982 to 2006; selected cohorts are labeled.

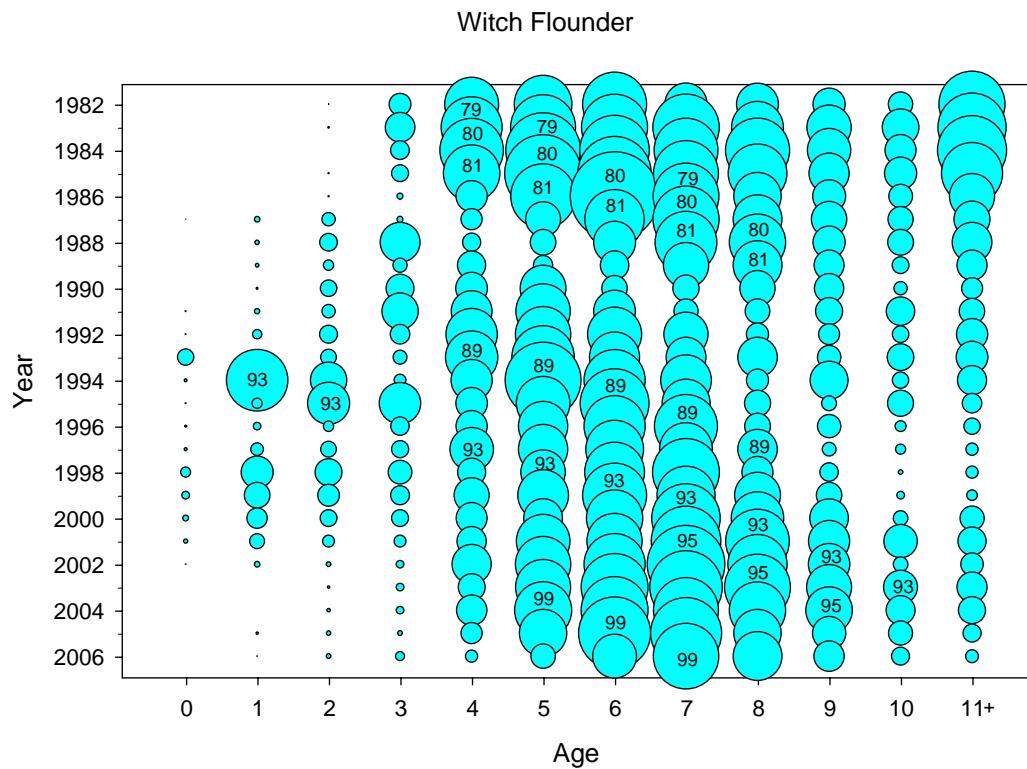


Figure G.3. Witch flounder catch at age (in numbers), 1982, 2006; selected cohorts are labeled.

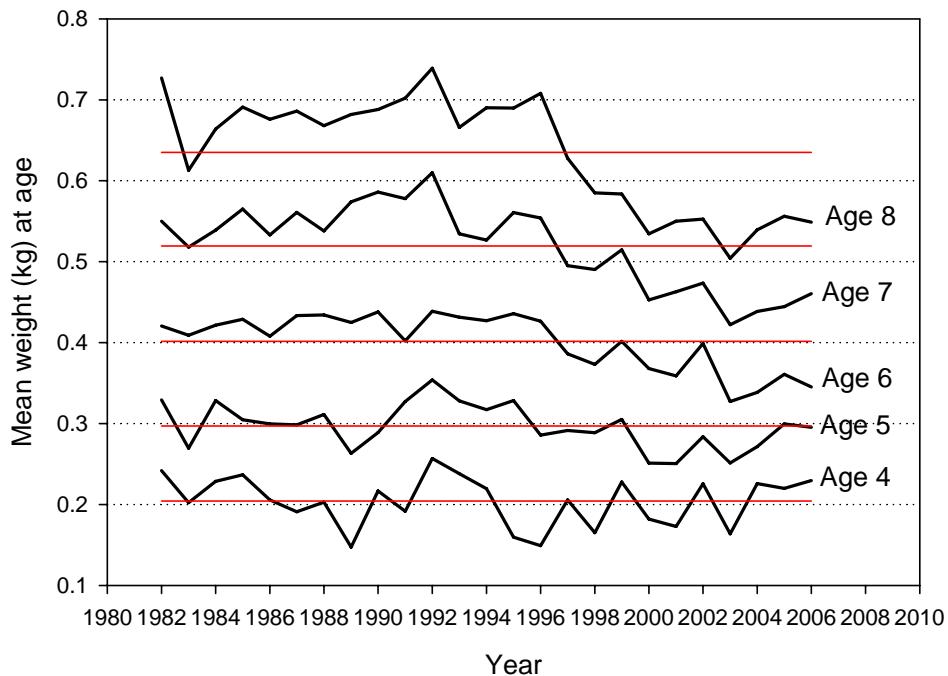


Figure G.4. Witch flounder mean weight at age in the catch, 1982 -2006.
Red line represents the 1982-2006 average for each age.

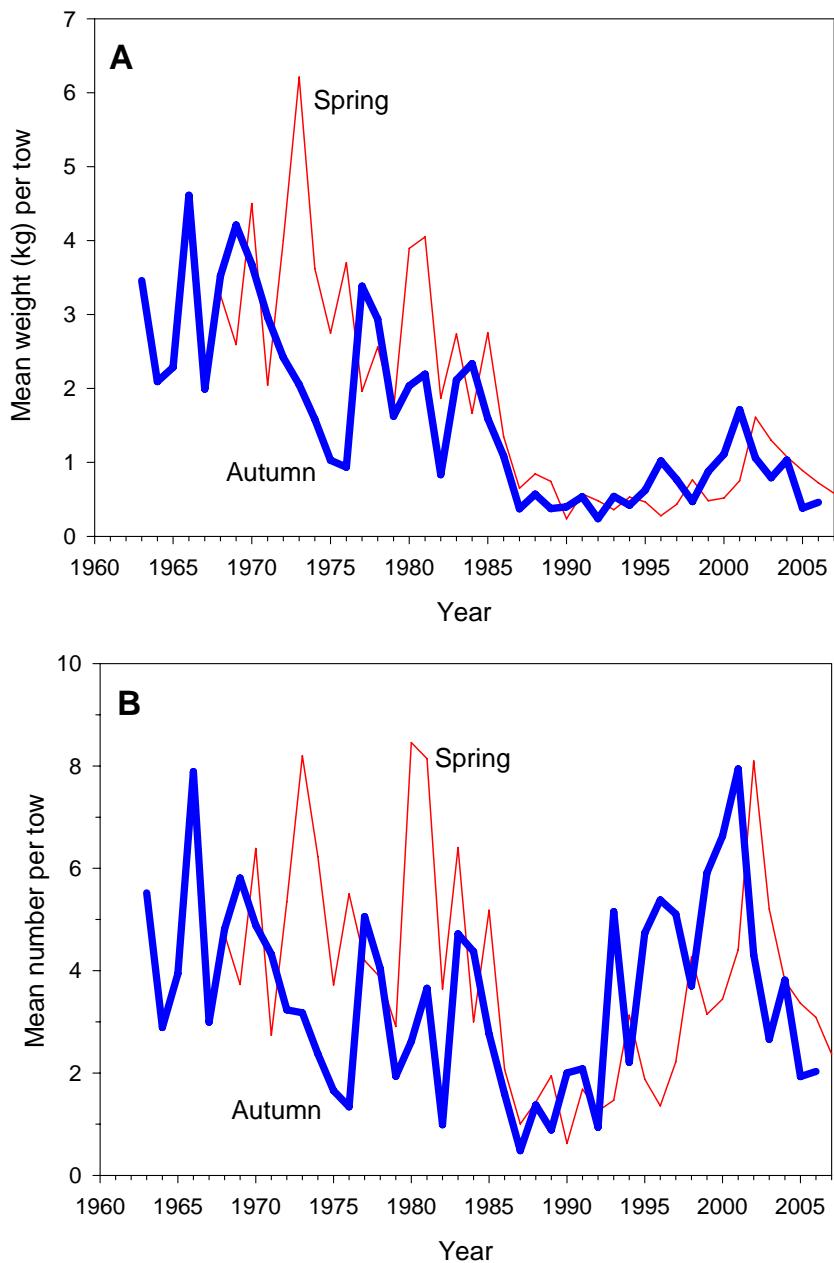
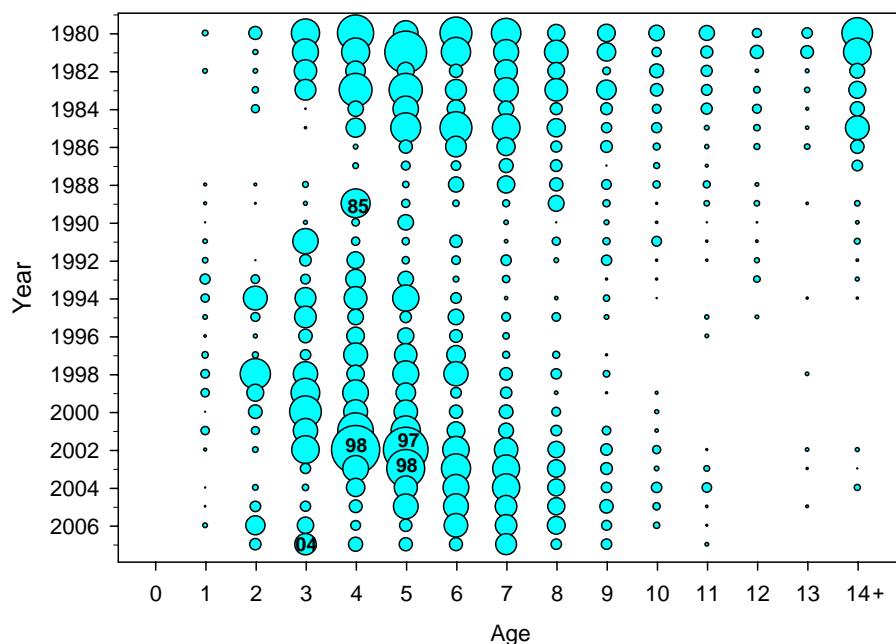


Figure G.5. Stratified mean weight (kg) per tow (A) and mean number per tow (B) of witch flounder in the NEFSC spring and autumn bottom trawl surveys, 1963-2007.

Spring Survey: Stratified mean number per tow at age



Autumn Survey: Stratified mean number per tow at age

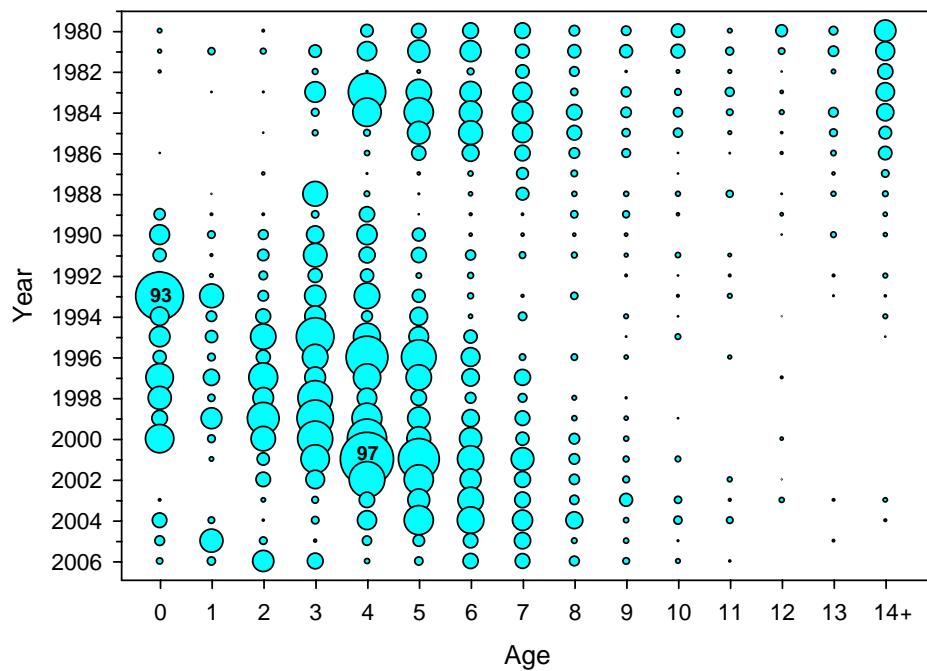


Figure G.6. Stratified mean number of witch flounder per tow at age from NEFSC spring (top) and autumn (bottom) surveys, 1982- 2006, spring 2007.

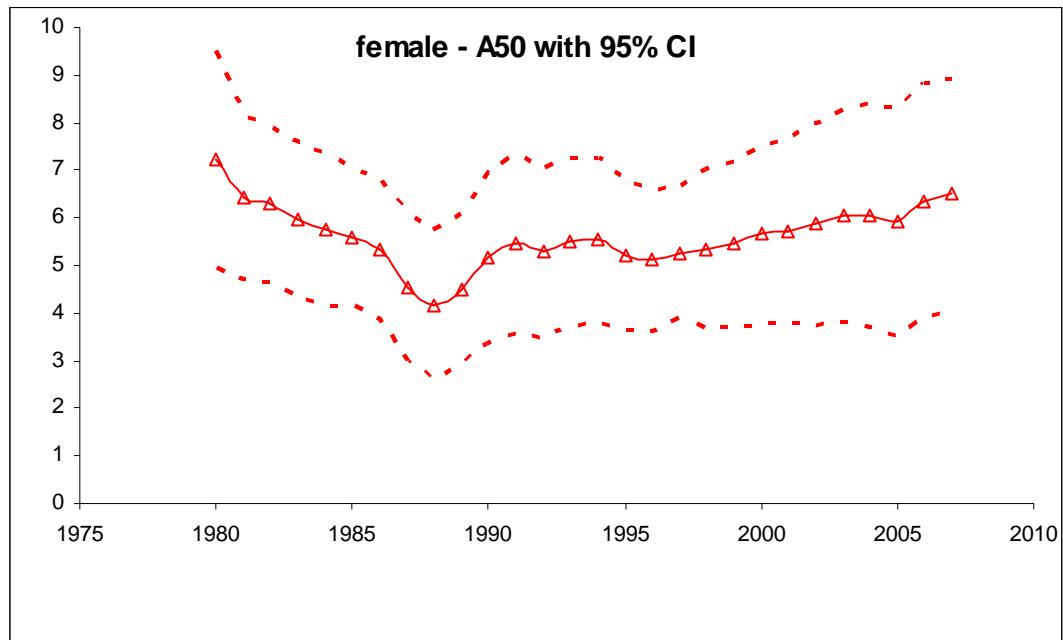


Figure G.7. Annual estimates of median age (A50) of witch flounder maturity derived from a five-year moving time block of maturity observations collected during the NEFSC spring survey, 1980 – 2007.

BASE RUN

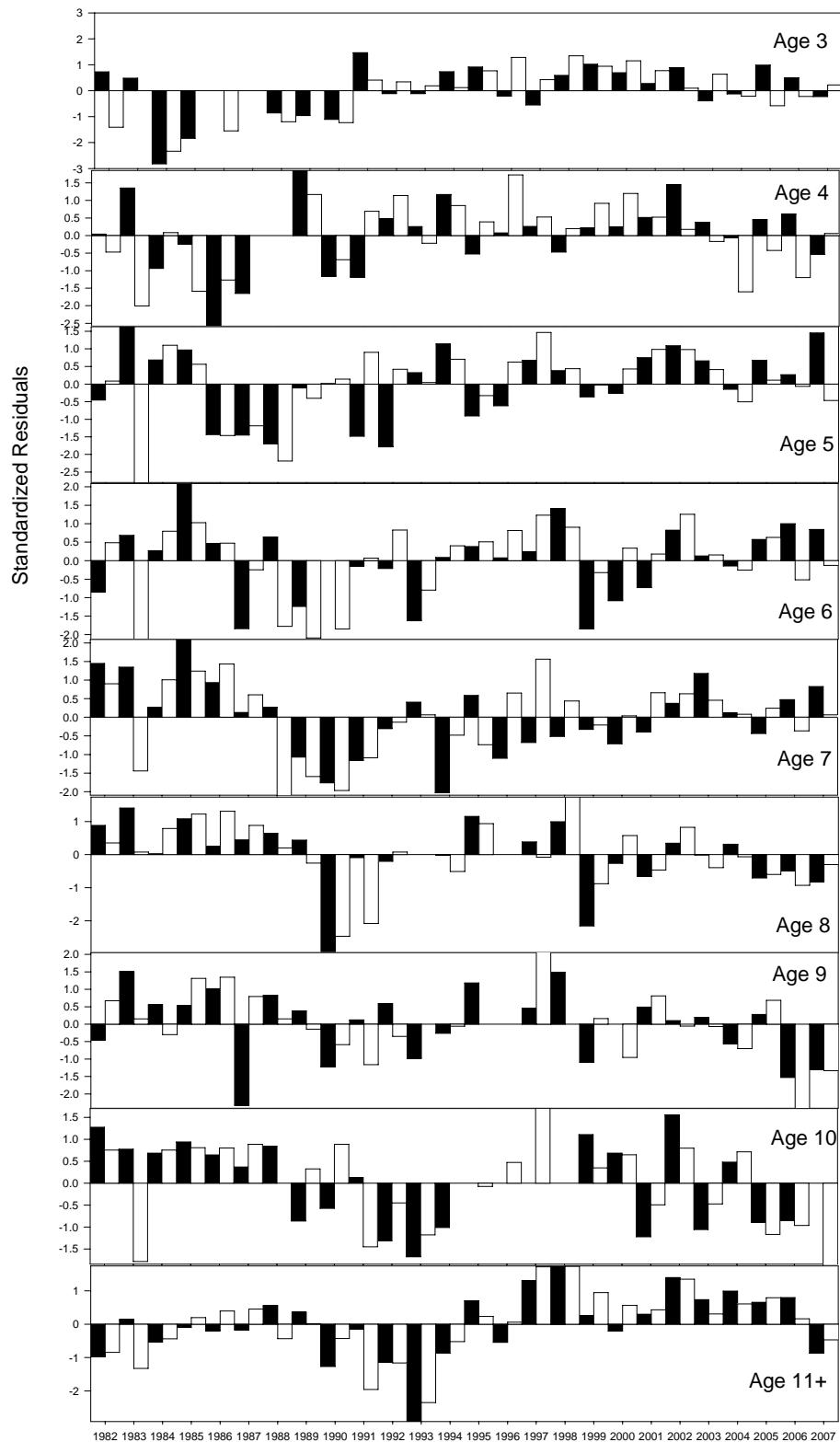


Figure G.8. Witch flounder standardized residuals for NEFSC survey indices (spring solid bar and autumn solid bar) at age; 1982-2006. **BASE RUN**.

BASE RUN

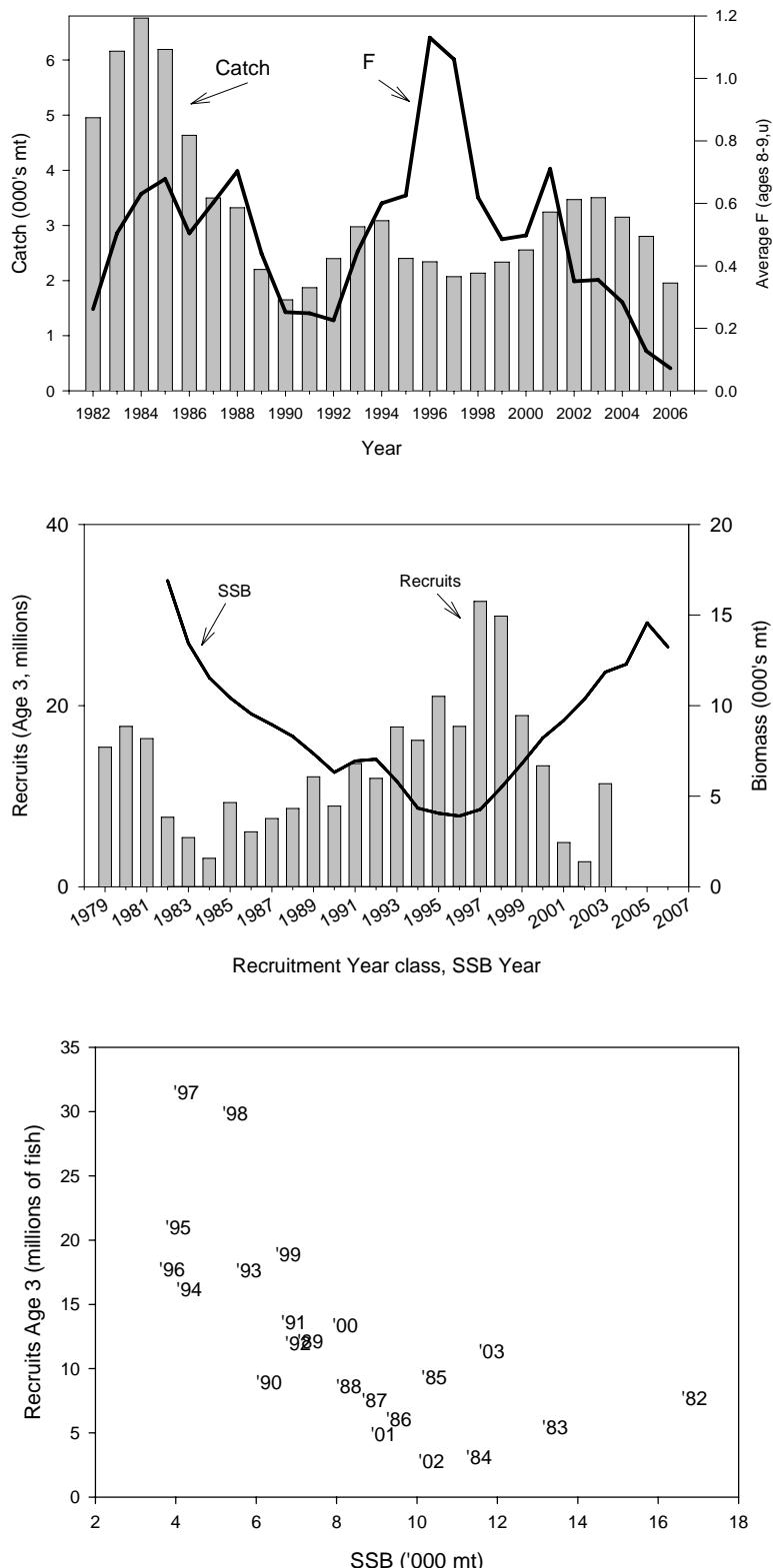


Figure G.9. Trends of witch flounder total catch and fishing mortality (top), spawning stock biomass and Age 3 recruitment (middle), and spawning stock biomass (thousands, mt) and recruits (age 3, millions), 1982 – 2003 year classes (bottom) from **VPA BASE RUN**, 1982 – 2006.

VPA BASE RUN

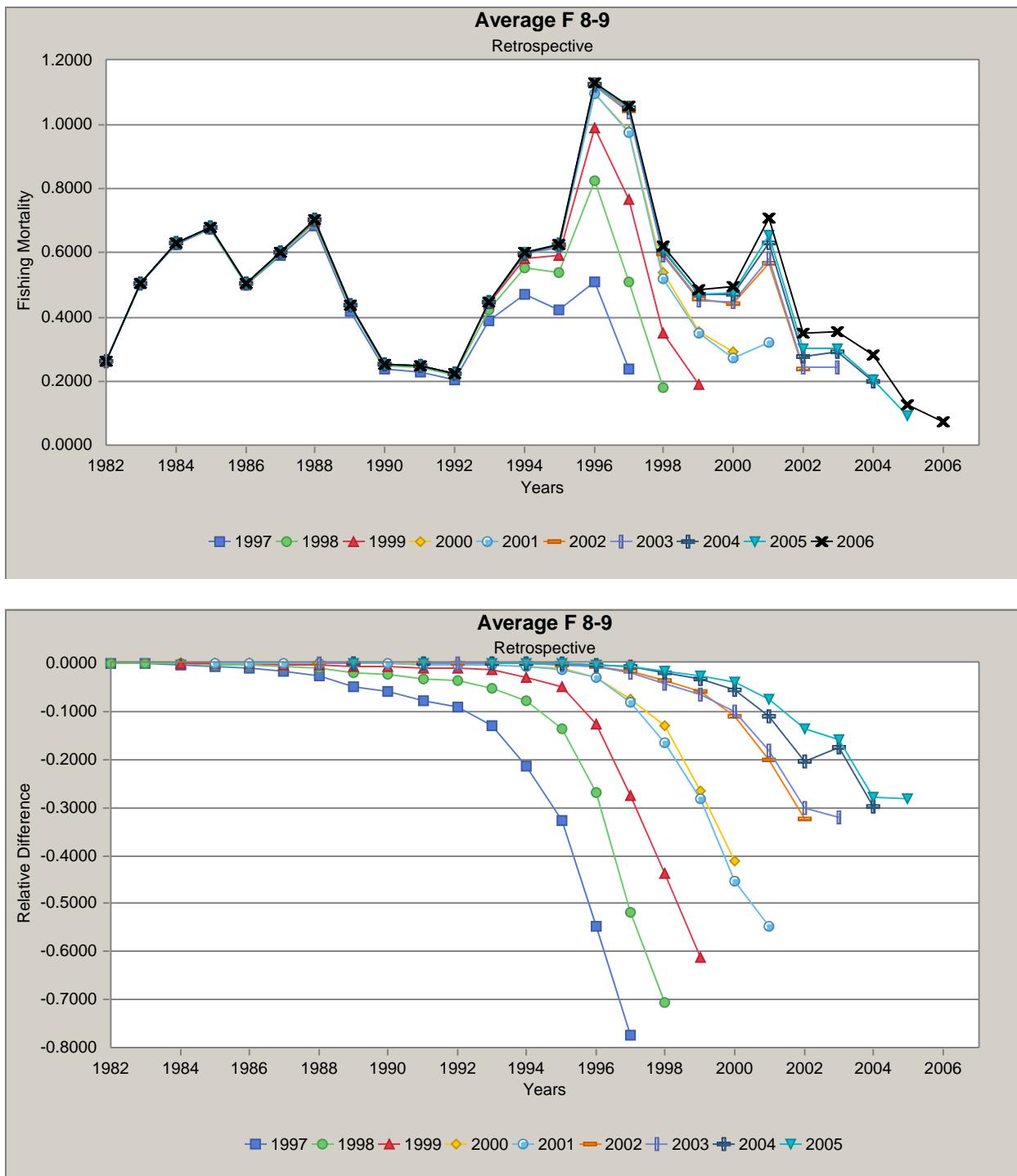


Figure G.10. Retrospective analysis results of fishing mortality (top) and relative difference of fishing mortality from the terminal year (bottom) from VPA **BASE RUN**.

VPA BASE RUN

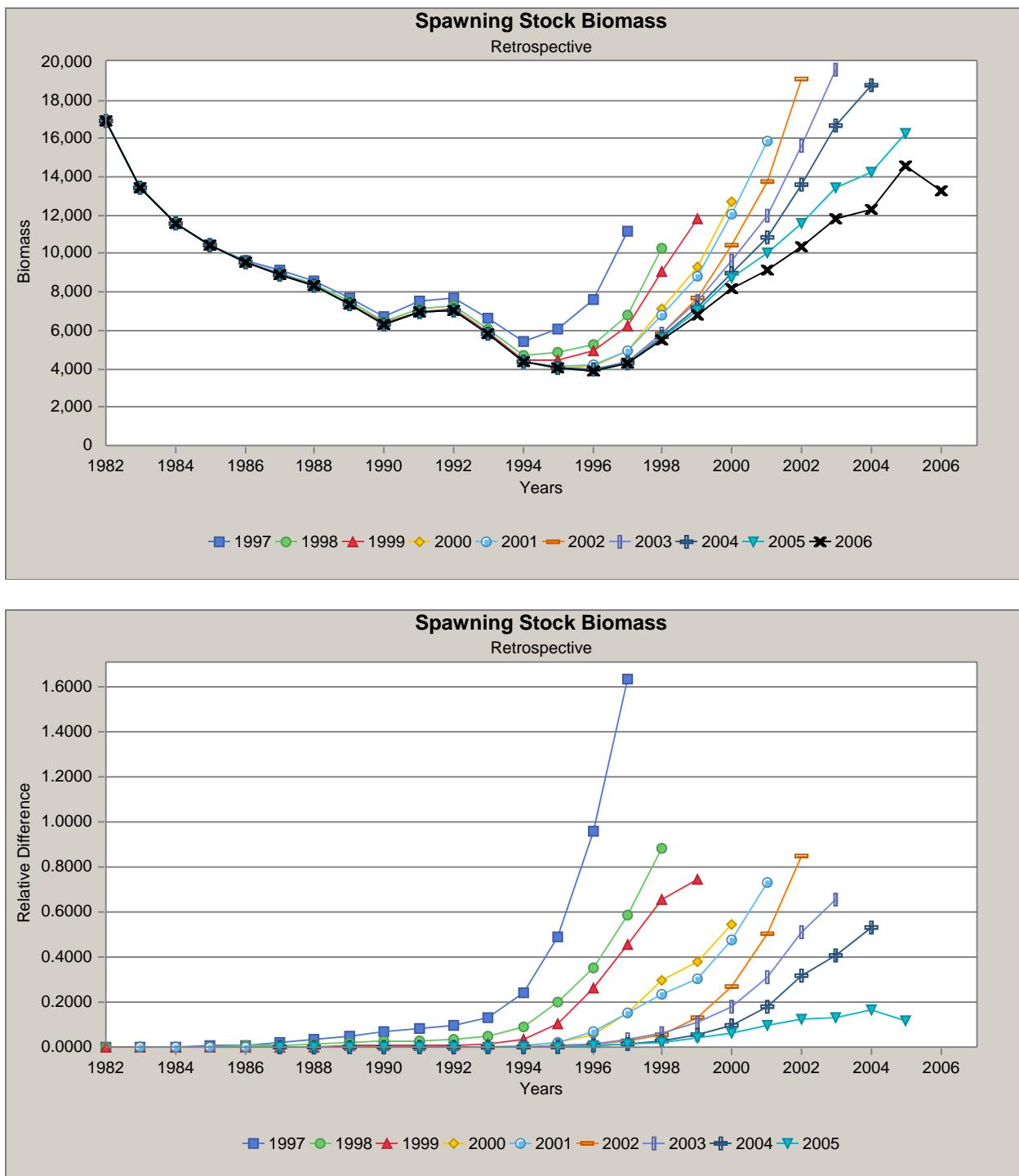


Figure G.11. Retrospective analysis results of spawning biomass (top) and relative difference of spawning biomass from the terminal year (bottom) from VPA **BASE RUN**.

VPA BASE RUN

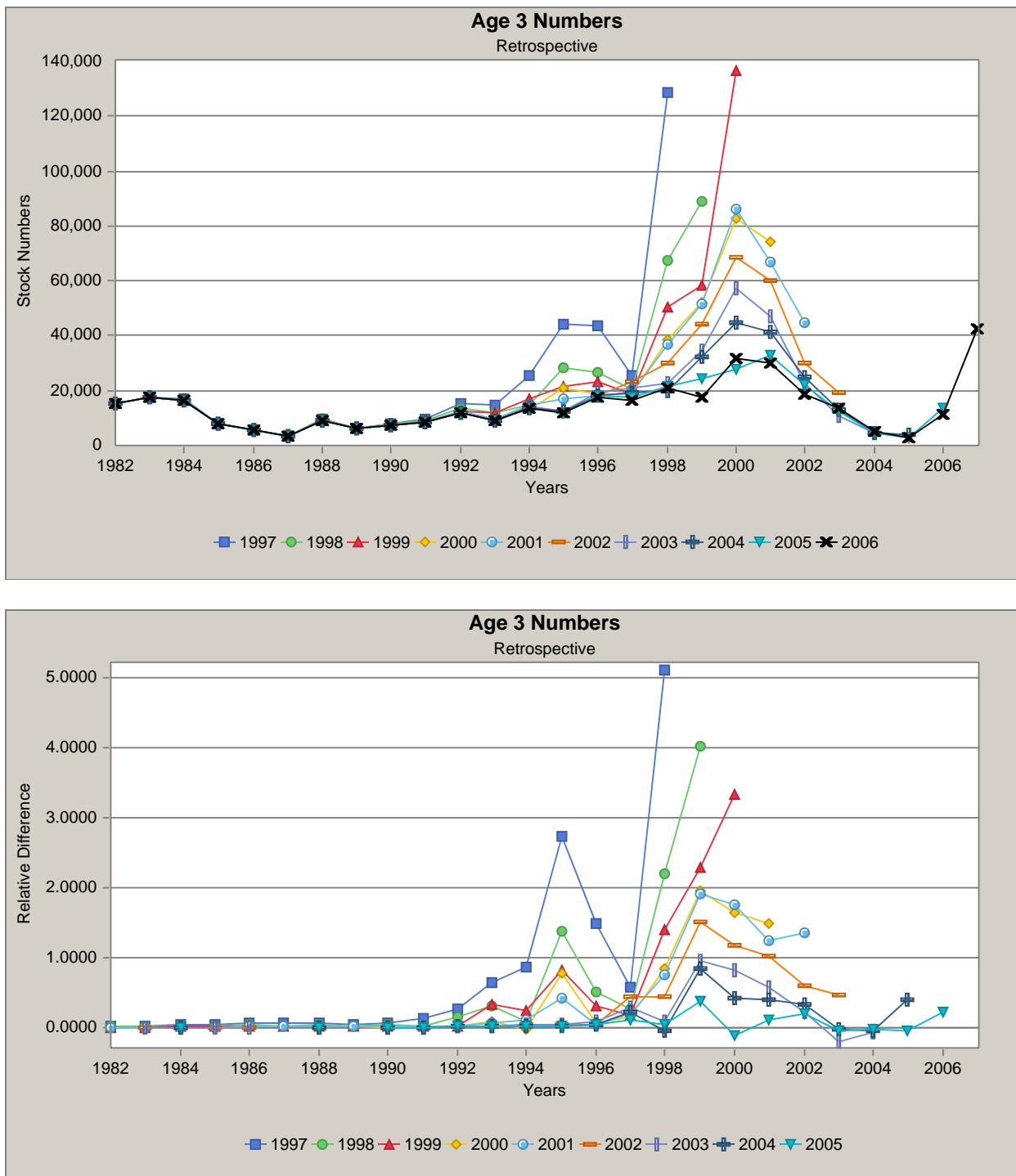


Figure G.12. Retrospective analysis results of Age 3 recruitment (top) and relative difference of Age 3 recruitment from the terminal year (bottom) from VPA **BASE RUN**.

SPLIT RUN

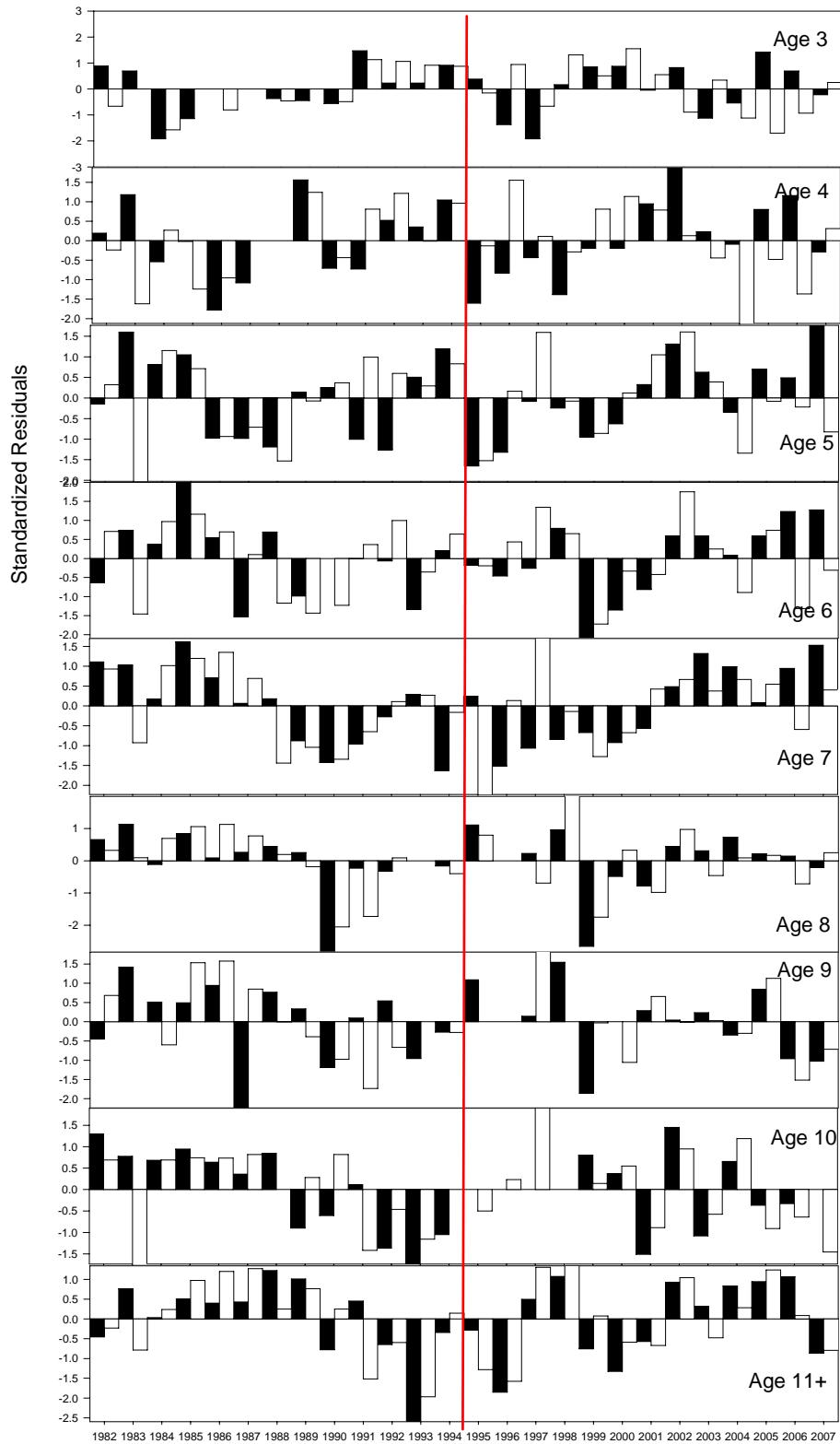


Figure G.13. Witch flounder standardized residuals for NEFSC survey indices (spring solid bar and autumn solid bar) at age; 1982-2006. Red line indicates the 1994 and 1995 split. **SPLIT RUN**

SPLIT RUN

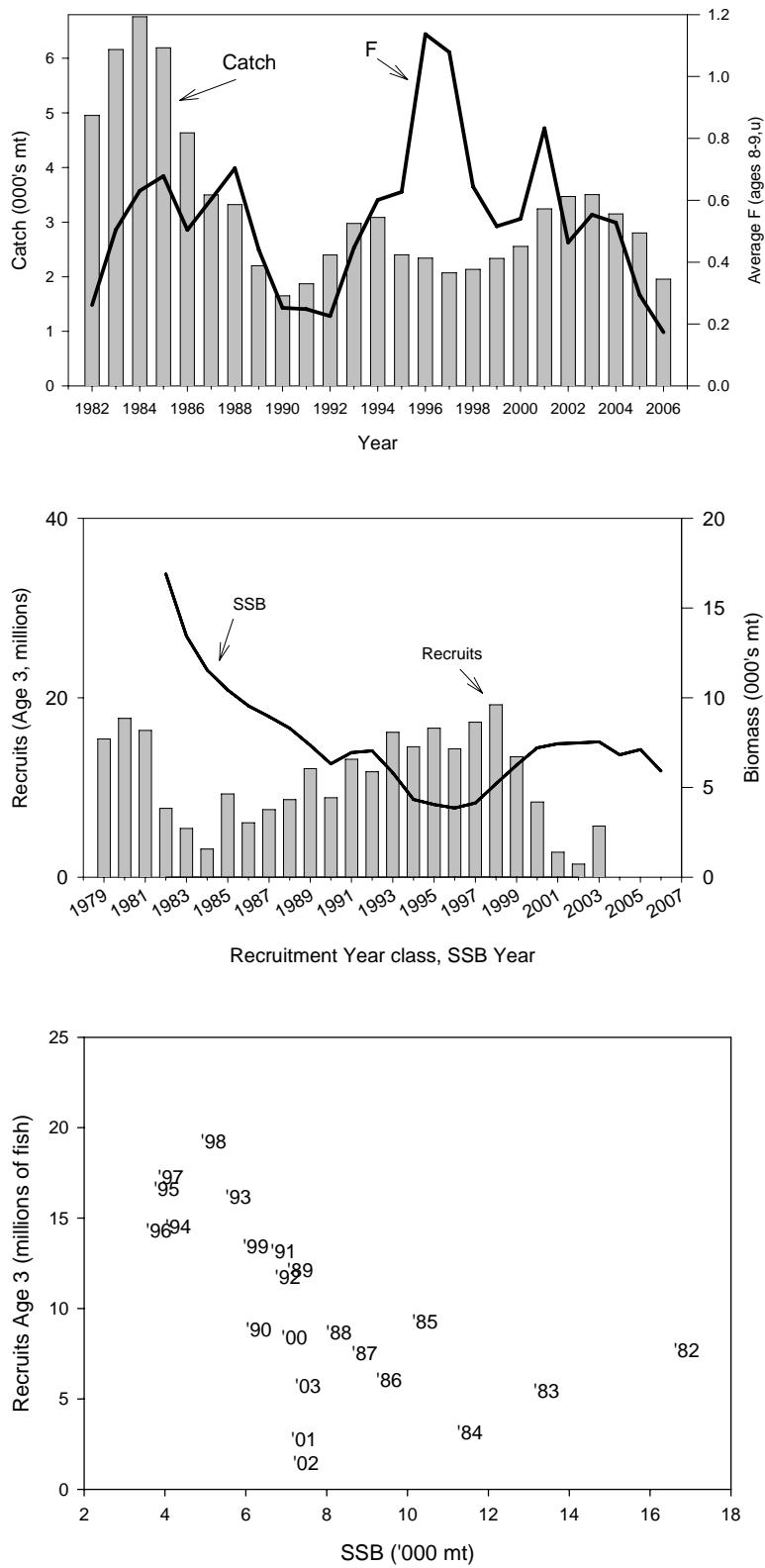


Figure G.14. Trends of witch flounder total catch and fishing mortality (top), spawning stock biomass and Age 3 recruitment (middle), and spawning stock biomass (thousands, mt) and recruits (age 3, millions), 1982 – 2003 year classes from **VPA SPLIT RUN**.

SPLIT RUN

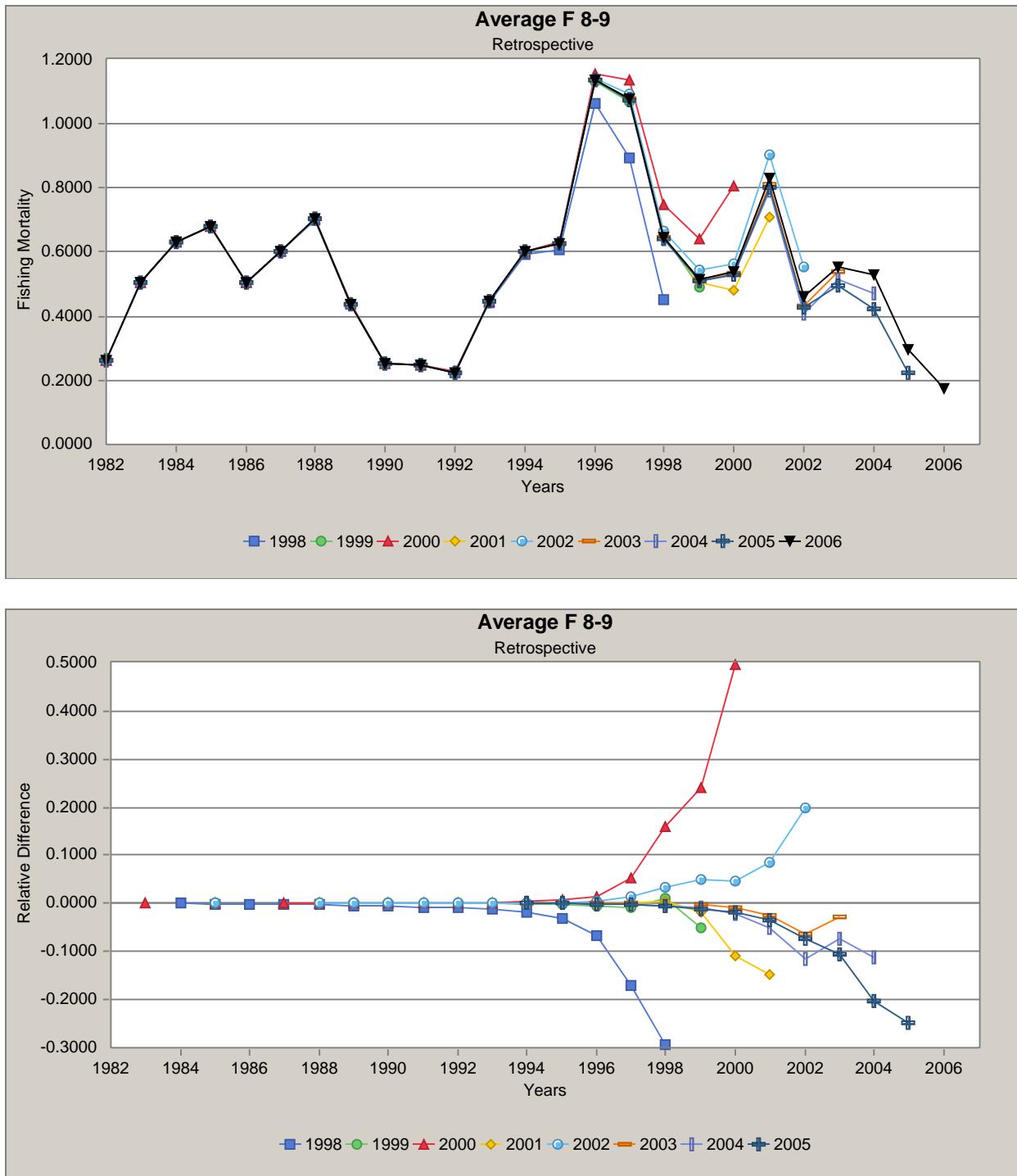


Figure G.15. Retrospective analysis results of fishing mortality (top) and relative difference of fishing mortality from the terminal year (bottom) from VPA **SPLIT RUN**, 1982 – 2006.

SPLIT RUN

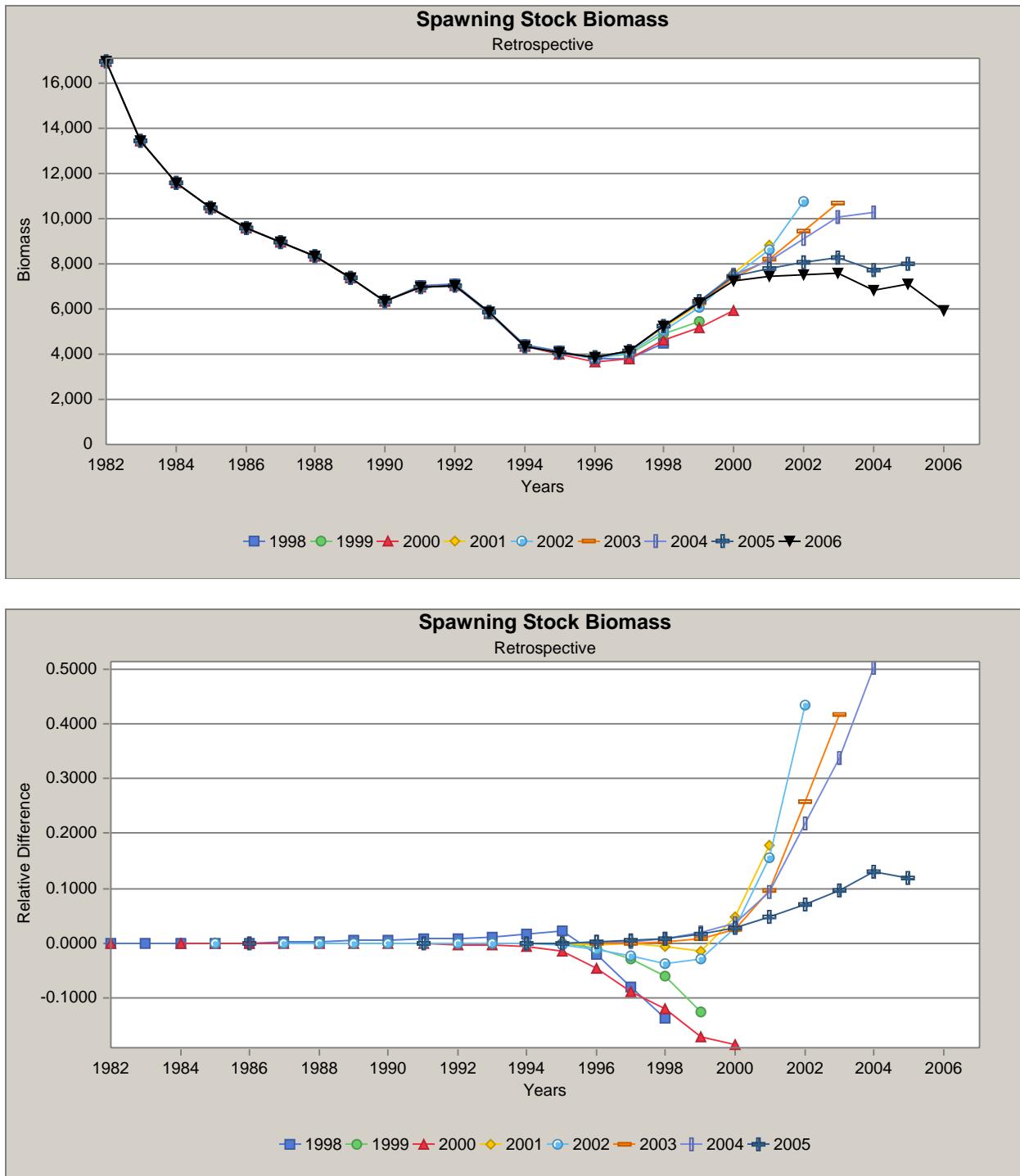


Figure G.16. Retrospective analysis results of spawning biomass (top) and relative difference of spawning biomass from the terminal year (bottom) from VPA **SPLIT RUN**, 1982 – 2006.

SPLIT RUN

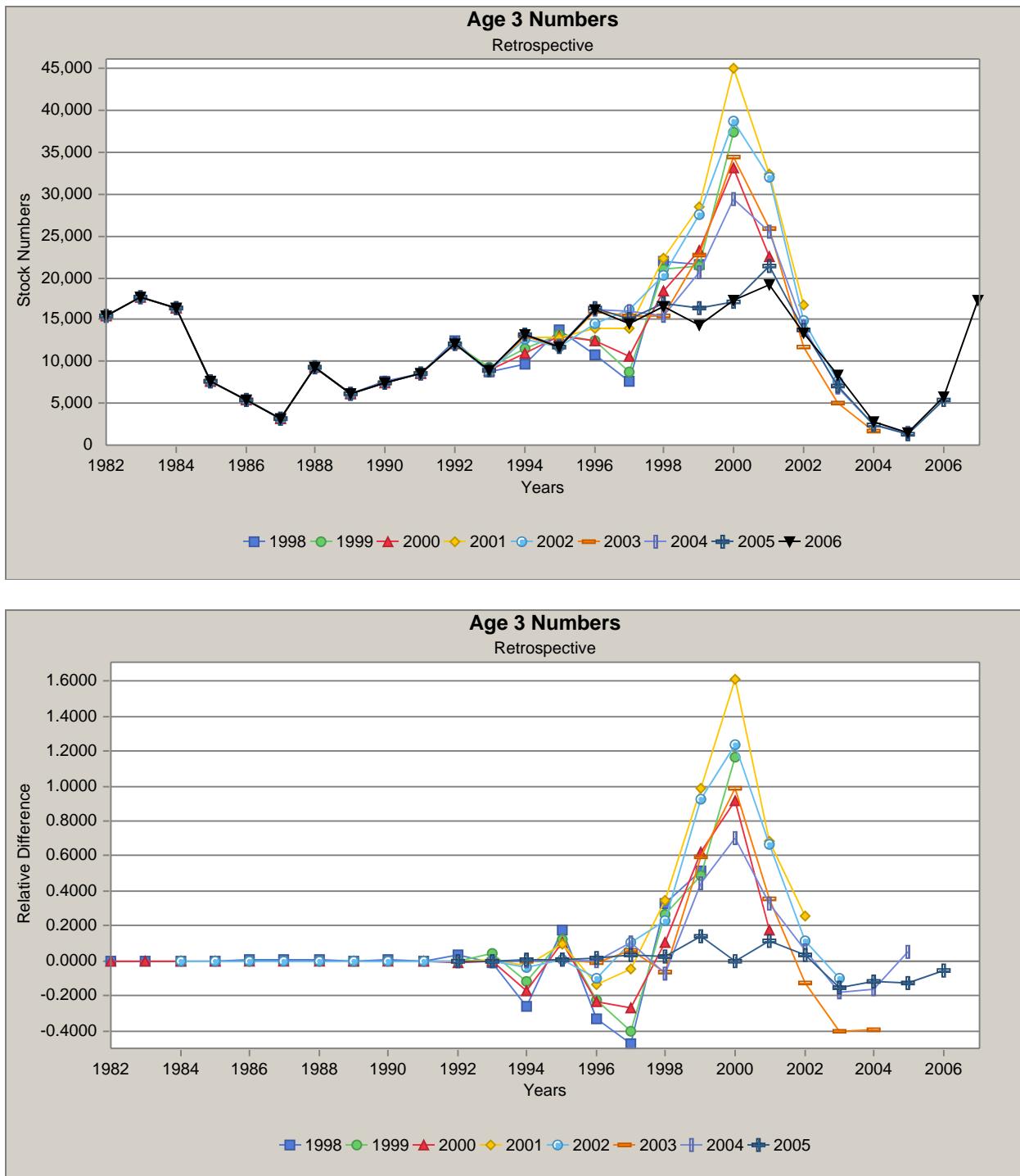


Figure G.17. Retrospective analysis results of Age 3 recruitment (top) and relative difference of Age 3 recruitment from the terminal year (bottom) from VPA **SPLIT RUN**, 1982 – 2006.

BASE RUN

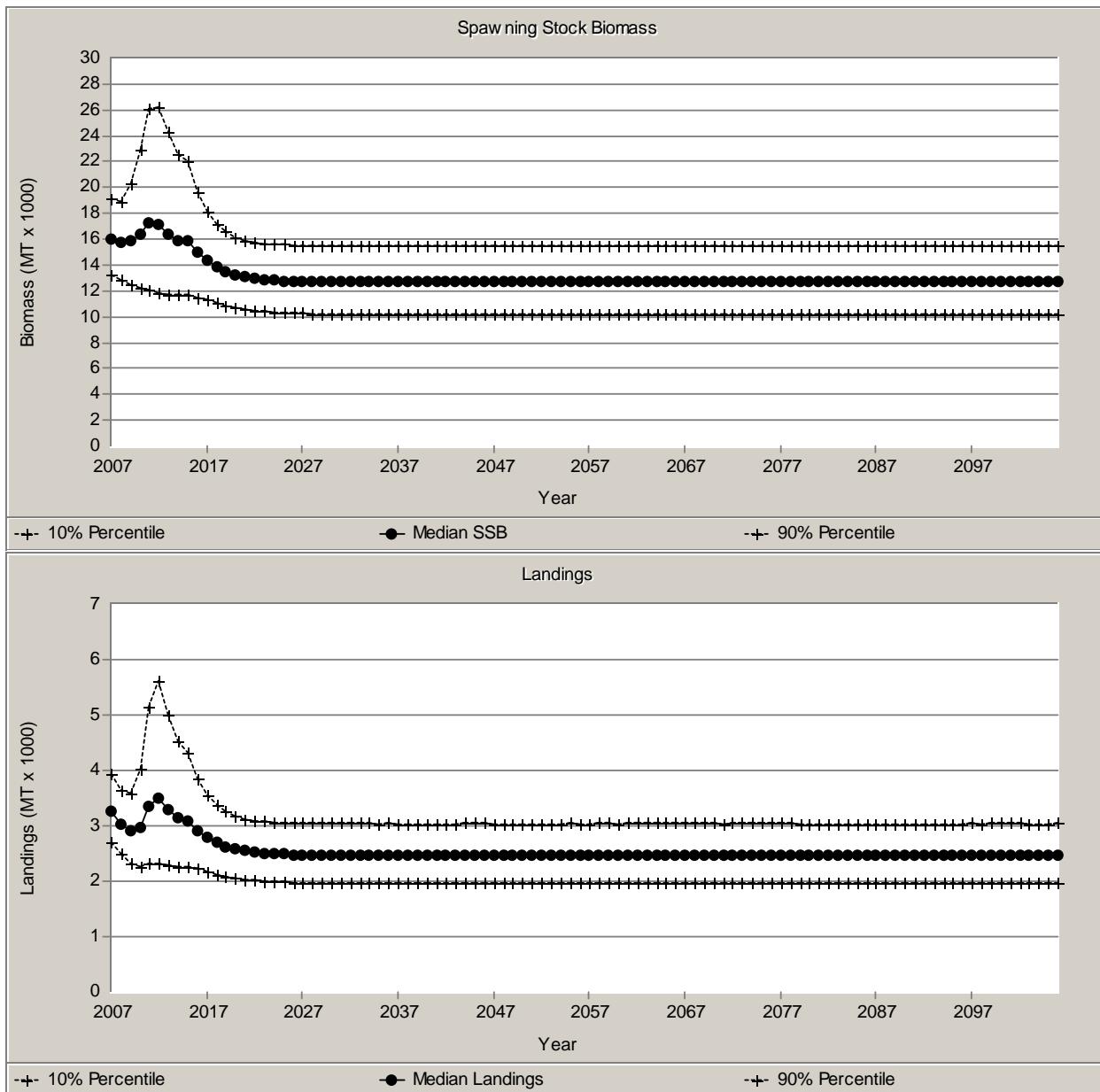


Figure G.18. Long-term (100 years) stochastic projections of witch flounder spawning stock biomass and landings deriving using a constant $F=0.22$ scenario and input vectors used in yield and spawning stock biomass per recruit analyses based on the VPA **BASE RUN**.

SPLIT RUN

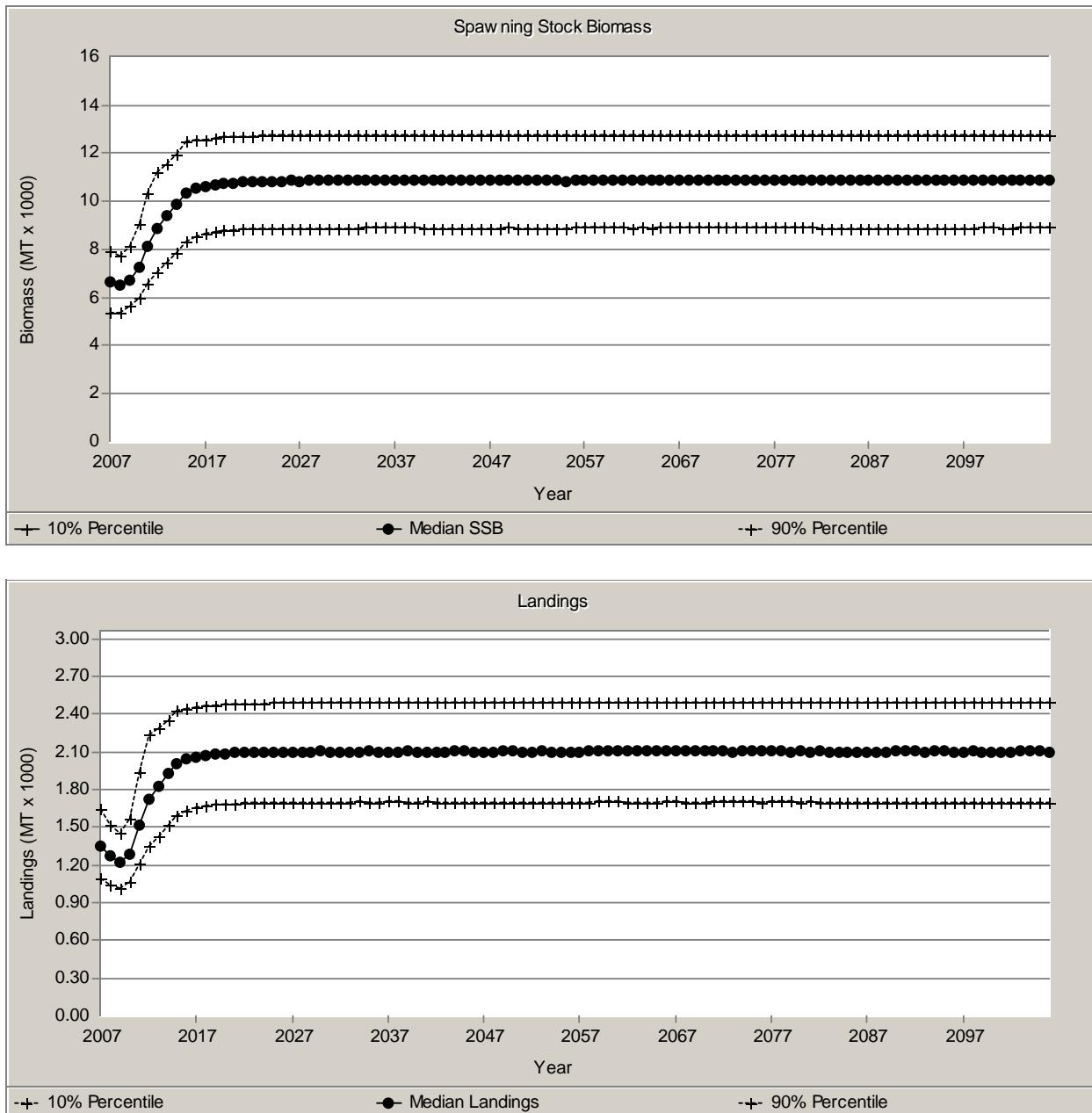


Figure G.19. Long-term (100 years) stochastic projections of witch flounder spawning stock biomass and landings deriving using a constant $F=0.22$ scenario and input vectors used in yield and spawning stock biomass per recruit analyses based on the VPA **SPLIT RUN**.